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THE SECOND TRUNNION BASCULE BRIDGE in this country has now been completed. This is the Clybourne Place bridge over the Chicago River, the first bridge of its type being that over the Milwaukee River at Grand Ave., Milwaukee, Wis., which was opened on March 10. The Clybourne Place bridge, which was described in our issue of Jan. 31, 1901, is 128 ft. long, between trunnions, and gives a clear waterway of 100 ft. There are three through trusses, 9 ft. deep at the ends (or the middle of the bridge), and 24 ft. deep over the trunnions, beyond which the top chord curves with a radius of 26 ft. 4 ins. The operating rack is attached to the curved heel of the truss, and gears with a driving pinion below the street level. There are two 18-ft. roadways and two 9-ft. sidewalks. The total weight is about 650 tons. The substructure was built by the Fitz Simons & Connel Co., and the superstructure by the American Bridge Co. The Grand Ave. bridge at Milwaukee is also a double-leaf deck bridge, with a length of 116 ft. c. to c. of trunnions. There are two half-through plate girders, and the operating racks are concentric with the trunnions. The bridge has a 36-ft. roadway and two 12-ft. sidewalks, while its total weight is about 720 tons. The Wisconsin Bridge & Iron Co., of Milwaukee, had the contract for both the substructure and the superstructure.

THE WEST WASHINGTON BRIDGE dispute at Indianapolis, Ind., has now been settled. The old bridge, which had been condemned and repaired, collapsed a few months ago under the undue load of an electric motor car hauling cinder cars, combined with a heavy gravel wagon. The city, having no funds to rebuild the structure, demanded that the county should do this, but the county authorities refused, although the citizens pay 90% of the county taxes, of which $50,000 to $100,000 is spent annually on bridge work outside the city. The city engineer was then directed to prepare plans for a concrete arch bridge, or stone arch bridge, and a plate girder superstructure on the existing piers. Before these were completed, however, the county reversed its position and decided to build the bridge, the county surveyor being in turn directed to prepare plans. The county's appropriation was about $150,000, while the lowest bid for a masonry arch was about $200,000. No satisfactory bid was received for a concrete-steel arch, although estimates had been made for the Melan and Hennebique systems. The contract was finally awarded to the Brown-Ketcham Iron Works, of Indianapolis, at $75,800 for the superstructure; and to Wm. Fife & Son at $9 per cu. yd. for stone masonry and 30 cts. per ft. for piling. The county surveyor estimates the total cost of the bridge at $147,000. The bridge will be 80 ft. wide, with a 60-ft. roadway and two 10-ft. sidewalks. This width was adopted for the reason that it is intended to concentrate the street railway traffic on this bridge, as far as possible, the lines diverging on the west side of the bridge. The construction of this new and wide bridge will necessitate the destruction of the old two-span covered wooden bridge which was built to carry the National Turnpike, and which has now been closed to all but pedestrian traffic for some years. Its west end adjoined that of the West Washington St. bridge, the two bridges forming a Y. Meanwhile a trestle has been built to carry the roadway and street railway across the river, while similar trestles have been built to support the other old iron bridges which have been condemned as dangerous, but which the city cannot replace for lack of funds.

THE NEW MISSISSIPPI RIVER BRIDGE, between Jamestown, Wis., and Dubuque, Ia., has two channel spans of 380 ft., with a single span of 150 ft. to the high bluffs on the Iowa side, and a 200-ft. span on the Wisconsin side followed by 1,824 ft. of trestle approach. The masonry piers are 52½ × 17½ ft. at the base and extend to a height of 35 ft. above the river bed; each pier carries two steel cylinder columns filled with concrete, the columns being 50 ft. high. The bridge floor is 55 ft. above high-water line. It is a highway bridge, built by a company organized among the local people, and cost about $110,000.

CONCRETE AND EXPANDED-METAL WALLS are a peculiar feature of the new buildings for the Portland cement plant of the Hecla Portland Cement & Coal Co., of Bay City, Mich. The buildings are of steel-frame construction, with expanded-metal sheeting between the columns, upon which the concrete is applied. For the building containing the storage bins the concrete is much heavier than in the other buildings, on account of the interior pressure. The roofs are partly covered with corrugated iron, and partly with wooden sheathing upon which is laid "standing-seam" iron roofing.

AN ENORMOUS ELECTRIC POWER PLANT at Chicago is projected by the Commonwealth Electric Co., the plant to have a capacity of 100,000 HP. and to cost about $6,000,000, while its construction will extend over four or five years. It will be located on the South Branch of the Chicago River, between Morgan and Center Sts., south of 22d St. Work is to be commenced at once and contracts are said to have been placed for machinery of 16,000 HP. It is thought that the plant will furnish current for some of the street railways, as well as for lighting and general power purposes. The company is closely related to the Chicago Edison Co., Mr. Samuel Insull being President, and Mr. Louis A. Ferguson, Vice-President and General Manager of both companies.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Chicago, Burlington & Quincy R. R. near Alma, Wis., on May 29. A gravel train was entering a side track when another gravel train ran into it at high speed. A number of officials of the railroad were on the first train. All of them were injured more or less; one was killed outright, another died the following day and a third is in a dangerous condition.

A LOCOMOTIVE BOILER EXPLODED on the Atlantic Coast Line R. R. near Manchester, Va., on May 27. Three men died as a result of the accident and several others were injured. The cause of the explosion is not known.

AN AUTOMOBILE RACE BROUGHT DEATH to two spectators and caused the injury of a number of others on May 31, on South Shore Boulevard, Staten Island, New York. A series of record runs was being held there under the auspices of the Automobile Club of America. A number of machines had already covered the course when an electric automobile of the Baker Motor Vehicle Co., Cleveland, O., started on an attempt to lower the world's record for a mile. After covering the larger part of the distance the machine ran wild in some manner not yet explained and dashed into the crowded mass of spectators lined up along the course. One man was killed instantly, another died the following day, and several others were seriously injured. The two men in the automobile were but slightly hurt. The course on which the races were held had a curve at about the point where the accident occurred. Somewhat further back a trolley line crossed the course. This course was a simple macadamized road, sharply crowned, and is said to be in no way suited for such high-speed running.

AN INSTRUCTIVE FIRE is one that is reported to have recently wrecked portions of a steel tank elevator plant belonging to the Canadian Pacific Ry. at Fort William, Canada. Just as in the case of a fire noted in these columns but a short time ago, it calls renewed attention to the necessity of complete fireproofing of every part of a building and the danger of careless and inflammable construction of some small apparently unimportant parts. According to the New York "Journal of Commerce," the plant consisted of a number of circular storage tanks of steel plate, adjacent to which were on one side the boiler and engine house, on the other the elevator tower. This latter was 40 × 100 ft. in plan and 146 ft. high; the framework and floors were of steel, the roof and sides covered with corrugated steel. On the two top floors were garner and scale bins, built of wood, occupying only part of the two floors. The elevating shafts were rectangular chutes, of wood on two sides. On the second floor of the building were four cleaning machines, framed in wood, mounted on an elevated wooden platform. On this floor had accumulated much refuse, chaff, etc., from the cleaners. The fire is supposed to have started by a spark from a locomotive setting fire to this accumulated inflammable material. Although there was apparently little food for the fire, the elevator house was completely wrecked. Two adjacent bins, with their contents of grain, were damaged by the fire.

AN ELEVATED RAILWAY FIRE in Chicago caused slight injuries to several passengers on May 29. A northbound train on the Northwestern Elevated R. R. was passing Erie St. when the motor car (smoker) caught fire from crossed wires and was quickly in a blaze. The train was stopped and the passengers from the smoking car transferred to the next car, but some jumped down upon the track. The motorman and several passengers were badly scorched. The fire department was called and extinguished the fire, traffic being stopped for about half an hour.

THE FAILURE OF THE DAM on Break Neck Run, near Connellsville, Pa., on May 29, is described as follows in a letter sent at the request of this journal by Mr. W. S. Kuhn, General Manager of the American Water-Works & Guarantee Co., Pittsburg, Pa.:

The facts are that there was a cloud burst in the valley above the reservoir, which has a drainage area, practically of 4½ miles. The down pour was so great that the large flood channel and large spillway, which have been ample to take care of all floods for the past 16 years, were overtaxed and the water flowed over the top of the dam its entire length to considerable depth. The dam was constructed of puddle, with concrete core wall, and the waste material during the construction was placed on the lower side of the dam. The water flowing over the top of the dam washed the lower side of dam badly, and finally, after support was gone, broke the core wall down in several places.

THE WATER TANK THAT FAILED at Sheffield, Ala., on May 20 was built of cypress and rested on a trestle built of 12 × 12-in. × 24-ft. oak and pine timbers. The tank was built in 1886, as a temporary structure, by the Sheffield Land Co., which was succeeded by the Sheffield Water Co. Uncertainty regarding proposed municipal works deterred the latter company from making projected improvements, but about two years ago new oak timbers were put beneath the tank. At about 11 a. m., May 20, the tank then being full, "without any warning or careening the whole superstructure gave way, and fell in an opposite direction from the 1½-in. iron rods that were guying the tank." By 2 a. m. of the next day connections were made so that direct pressure was given. Negotiations for putting in a new and complete plant are now pending. For the foregoing information we are indebted to Mr. C. B. Ashe, President of the Consolidated Water, Light & Power Co., Sheffield, Ala.

THE PER DIEM CAR-SERVICE RATE for which agitation has been in progress for some time will go into effect on July 1, 1902, according to an announcement made by the American Railway Association. At present payment for the use by one road of the cars of another road is based upon the number of miles run by the car, the rate being 0.6 ct. per car mile. After July 1 the payment will be based upon the length of time that the car has been kept, at the rate of 20 cts. per day, with certain penalties for the use of the car longer than a prescribed period.

A FAST RAILWAY RUN on the Pennsylvania R. R., May 8, was incorrectly noted in our issue of May 15 as having been made between Harrisburg, Pa., and Morristown, N. J. It should have read between Harrisburg, Pa., and West Morrisville, N. J. (via the Trenton cut-off). We are informed by Mr. J. B. Hutchinson, General Manager of the Pennsylvania R. R., that on May 16 an almost exactly similar run was made between the same two points, the distance of 125 miles being covered in 125 minutes. The record is as follows:

Train No. 16, May 16, 1902.—Engine 508 (Engineman F. K. Miller), 1 combination car, 1 coach, 5 sleepers.

Distance between.	Station.	Time passes.	Time between
	Harrisburg.	4.30 p. m.	
10.0 miles.	Branch intersection.	4.42 "	12 mins.
8.5 "	Elizabethtown.	4.50 "	8 "
11.0 "	Landisville.	5.01 "	11 "
9.1 "	C. G. Block Sta.	5.10 "	9 "
10.1 "	Leaman Pl.	5.20 "	10 "
13.0 "	Parkesburg.	5.35 "	15 "
11.5 "	Downingtown.	5.45 "	10 "
7.2 "	Glen Loch.	5.54 "	9 "
11.5 "	King of Prussia.	6.04 "	10 "
10.2 "	Fort Hill.	6.12 "	8 "
6.5 "	S. N. Block Sta.	6.19 "	7 "
8.6 "	A. R. Block Sta.	6.25 "	6 "
8.5 "	West Morrisville.	6.35 "	10 "
125 miles.			125 mins.

REVETMENT WORK ON THE MISSOURI RIVER; CHICAGO & ALTON RY.

By W. R. De Witt.*

For a number of years the tracks of the Chicago & Alton Ry., in the vicinity of Cambridge, Mo., on the right bank of the Missouri River, have been seriously threatened by destruction from the ravages of the swift and devastating current of the river, for a distance of four miles. In 1880 and 1881, the U. S. Government took the matter up in the general improvement of the river, and constructed some 9,000 lin. ft. of revetment, but as this did not cover the entire stretch of threatened bank, it became necessary, in 1889 and again in 1901, for the railway company to do something for self-preservation. In 1889, about 4,000 lin. ft. of revetment was constructed by the then owners of the Chicago & Alton Ry., and is standing to-day in a good state of preservation. In 1901, the situation again became serious, and it was necessary to prevent further erosion of the river bank below the work built in 1889, which was done by extending the old revetment 8,250 lin. ft.

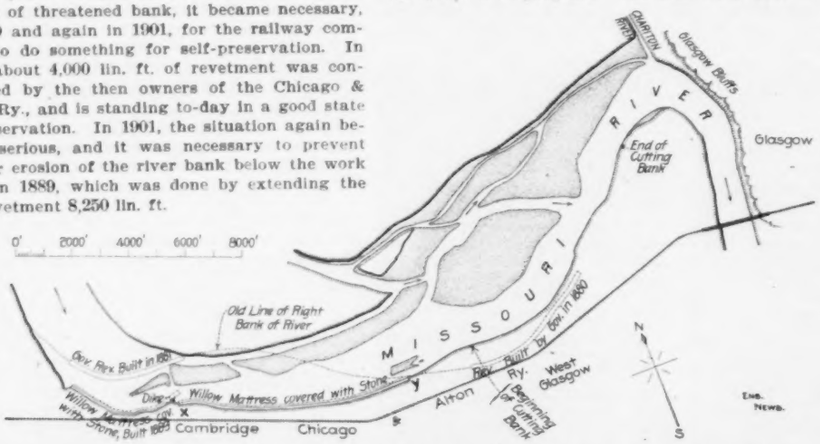


FIG. 1. MAP OF REVETMENT WORK ON THE MISSOURI RIVER; CHICAGO & ALTON RY.

Before determining the nature of the new work to be done, Mr. H. F. Baldwin, M. Am. Soc. C. E., the present Chief Engineer of the railway company, investigated the matter thoroughly, and became convinced that the most effective work possible was revetment, built in accordance with the plan of the U. S. Government. This same plan had been adopted by the railway company in 1889, and the good condition of that work in 1901, twelve years after construction, had great weight in determining the nature of the new work. It was finally decided, therefore: First, that the new work should be revetment, and second, that it should be constructed in accordance with the plan of the U. S. Government, with all of the improvements that have been made from time to time. The President of the Missouri River Commission detailed the writer to superintend the work of construction, upon request of the chief engineer of the railway company. As an interesting piece of engineering work, and with the hope that other railway companies in similar trouble will derive benefit therefrom, the work, in all its details, is described below. A map of the country in the vicinity of the work is shown in Fig. 1. The length of the bank between X and Y, 8,250 lin. ft. in extent, is that part protected by the work of 1901.*

The general design of the revetment work is shown in Fig. 2. The work is begun at the upstream end and carried downstream, so that the current does the work of moving all plant while the work is in progress. The first work done is that of grading the bluff (bank) to a slope of 1 on 2 between the limits of 2 ft. above standard high water, and 3 ft. below standard low water, if possible to reach the latter. This is generally possible if the work be done after the June rise, and the river has quieted down to its usual low summer stage. This work is done by means of a hydraulic grader, a boat or barge containing a force pump, a boiler and all necessary connections. The pump throws a stream through a 4-in. hose, on the end of which a nozzle with a tip of 1¼ or 1½ ins. With a pressure of 100 lbs. per sq. in., th throws a cutting stream that grades th throwing all surplus material out into the which carries it away, and leaves the slop in the rear as true and smooth as if a pl passed over it.

The grading force at work, and the ma handling the stream of water are shown in 3. The nozzle is fitted with a lever and a swi pin of which is dropped into a piece of ir previously driven into the ground, enabl nozzleman to direct the flow to any point The nozzleman has two assistants (laborer shift the hose between the nozzle and pum time to time as directed. When the upper is graded and the surplus earth thrown o the current, the nozzle is moved down the near the water surface, and the grading com under water. The entire grading force co of 1 steam-engineer, 1 fireman, 1 watchm nozzleman and 2 laborers. Under average conditions of soil and velocity of the current, this force will grade 100 lin. ft. of bank, or an average of 800 cu. yds. of earth in a day of ten hours.

The grading is followed up closely with the work of weaving a willow brush mattress, later to be sunk to the bed of the river. Having no regular mattress boat on which to weave the mattress for this piece of work, two barges, 20 × 50 ft., were lashed end to end, and a platform and a set of ways constructed thereon. The mattress boat thus constructed, a supply barge loaded with willow brush, and the actual work of weaving the mattress are shown in Fig. 4. The weaving is done on the ways. When the top of the ways is reached, the mattress is held up by the men, and the mattress boat allowed to drop downstream, until the work is again at the foot of the ways.

This mattress is woven of willow brush, 1 to 2 ins. in diameter at the butt, and 15 to 25 ft. in length, the stitch being over and under, as shown in Figs. 2 and 4. It is 12 ins. thick and 86 ft. wide, with a selvedge on both the inshore and outstream edges, and is strengthened and held in place by a system of cables. The line of the inshore edge of the mattress follows a contour line, 3 ft. above standard low water. Five sets (two to the set) of ⅝-in. galvanized cables are run longitudinally, one cable under the mattress and one on top, spaced as shown in Fig. 2, and a single cable is run in the inshore selvedge. Similar sets or pairs of cables are run transversely, at intervals of 16 ft. 8 ins., one cable under the mattress and one on top. An iron clip made of 7-16-in. iron, as shown in detail in Fig. 2, is used to fasten the longitudinal and transverse cables together at their intersections. The transverse cables are

FIG. 3. HYDRAULIC GRADING OF RIVER BANK, PREPARATORY TO CONSTRUCTING MATTRESS.

FIG. 7. COMPLETED REVETMENT WORK ON THE MISSOURI RIVER BANK; CHICAGO & ALTON RY.

*Assistant Engineer, Chicago & Alton Ry., Glasgow, Mo.; formerly U. S. Assistant Engineer.

*The curved dotted line crossing the channel, in Fig. 1, shows the old position of the right bank of the river, having a reverse curve between the two pieces of revetment work built by the U. S. Government in 1880 and 1881. At the west end, the river has shifted south so far as to destroy the old revetment work, and to bring the present left bank south of the old right bank. At the east end, the river has shifted north, so as to leave the old revetment inland. The east end of the railway company's revetment work of 1889 was curved to the line of the old channel, as shown, but this has been cut away with the shifting of the channel, and a curved dike or levee of 350 ft. radius now lies between the revetment work done in 1889, and that done in 1901. The work is a short distance west of the Glasgow bridge of the C. & A. Ry., the reconstruction of which was described and illustrated in our issue of March 14, 1901.—Ed.

run to deadmen, planted on the main bank, 8 ft. back from the top of the slope. These deadmen or anchors are yellow pine timbers, 12 × 12 ins., 4 ft. long. In order to facilitate placing the iron clips, boxes 12 ins. square and 4 ft. long, open at both ends, are placed at each intersection of the cables, and the mattress woven around them. When the work of weaving the mattress has passed one set of transverse cables, the clips are put in place and the boxes removed. They are shown, lying on top of the mattress, in Fig. 4. Before fastening the clips, the slack is taken out of the cables with a set of blocks and falls.

The mattress force consists of 1 foreman, 10 laborers skilled in weaving, 10 brush passers (one to each weaver), 3 laborers to keep the brush passers supplied with brush from the supply barge, 5 laborers in the cable gang, 3 laborers to dig and fill up deadmen holes, and a water boy; or 33 in all. This force will weave, on an average, 90 lin. ft. of mattress in a day of ten hours.

As the mattress boat moves downstream, it leaves the mattress behind it afloat on the water surface, until a sufficient length of mattress is woven to make it safe to sink (that is, when the work of sinking can be commenced and proceeded with without pulling the mattress off the ways of the mattress boat, which is fixed by the depth of water and the velocity of the current). A loaded barge of stone, each of the stones weighing from 100 to 200 pounds, is then swung across the mattress, which is sunk to the bed of the river by having the stone equally distributed over it. As the mattress sinks, the barge is dropped downstream, broadside, and the work continued. That branch of the work is shown in Fig. 5. This work is done either by the mattress party or the force engaged in paving the bank, according to circumstances. A gang of 30 men will in three hours empty a barge containing 150 cu. yds. of stone, which will sink 200 lin. ft. of mattress.

After the mattress is sunk, the inshore edge is faired up with spawls or crushed stone, and between the limits of 3 ft. above and 3 ft. below standard low water, spawls are distributed in quantity sufficient to fill the interstices in the mattress. This work, completed, is shown in Fig. 6, which also shows the work of paving the bank in progress.

The next branch of the work, in order, is that of paving the sloped bank, just mentioned as being shown in Fig. 6. This work is commenced at the top of the bank (or at a contour line 2 ft. above standard high water, should the bank be found higher than that elevation), and shingled down the slope. This is done with one-man stone, and is carried as far into the water as the men can reach, the thickness or depth of the paving at the top of the slope being 8 ins., increasing to 12 ins. at the water line. A force of 4 pavers and 28 wheelers will pave 100 lin. ft. of bank, having a slope 54 ft. long, or 5,400 sq. ft., in a day of ten hours, when the stone is delivered to them on a barge at the foot of the slope.

In the early days of revetment work, the stone was merely thrown on the slope and not paved, but this was soon improved on, and it was found that the extra cost of setting each stone in place was well repaid by the stability of the work. The work of paving is begun at the top and worked down the slope, instead of being begun at the bottom and worked up, for two reasons: one reason is that each stone is self-supporting, and the other is that as the stones point away from the water instead of toward it, they catch and hold all sediment, as the river rises and falls.

The next and last branch of the work is that of placing a 2-in. layer of spawls or crushed stone on top of the paving from the top of the slope to the contour 3 ft. below standard low water, thus filling all cracks and crevices with fine particles of stone and preventing washouts from surface drainage. Some of this work, completed, is shown in Fig. 7.

The average cost of 100 lin. ft. of revetment, as thus constructed, is shown in the following estimate, which varies, of course, with the locality, the amount of work to be done, the proximity to the work of willow brush patches and stone quarries, and with the method of transporting materials to the work, whether by rail or by steamer, and if the latter, whether the loaded trips are up or down stream.

Estimated Cost of 100 lin. ft. of Revetment.

Grading Bank: Labor	$10.25	
Fuel and engineman's supplies	2.25	
		$12.50
Weaving Mattress: Labor	$55.22	
Materials:		
60 cords willow brush, $1.75, delivrd	105.00	
800 lbs. ⅝-in. galv. cable, at 4 cts.	32.00	
48 7/16-in. iron clips, at 5 cts. each	2.40	
6 deadmen, 12x12 ins, 4 ft., Y.P., $1	6.00	
		200.62
Ballasting Mattress: Labor	$0.50	
Materials: 75 yds. stone at $1, delivered	75.00	
		81.50
Paving Bank: Labor	$51.70	
Materials: 150 yds. stone, $1, delivered	150.00	
		201.70
Placing Spawls: Labor	$15.43	
47 cu. yds. spawls, 50 cts., delivered	23.50	
		38.93
Total		$535.25
Administration	$18.25	
Care of plant	7.50	
Current repairs to plant	1.50	
Hire of plant	100.00	
Surveys	5.00	
Ice	3.00	
Towage, other than for stone and brush	8.25	
		$143.50
Add 10% for contingencies		67.87
Grand total		$746.62

This is a very fair estimate of cost, when it is necessary to hire the required plant. This (in addition to a small steamboat) ordinarily should consist of one grader, one mattress boat and six barges, 25 × 100 ft., if all of the materials are transported by steamer, as in the case of the work just completed for the Chicago & Alton Ry.

It is contended by the writer that revetment is by far the most economical work, where the mere preservation of the bank line is desired. The willow mattress, forming the foundation of the work, if properly anchored, forever protects the bank from undermining, as it never decays under water. The future work, therefore, is a mere problem of keeping the upper bank protected, and this can be done by the addition of a little stone placed at intervals of years. Of course, similar results could be obtained by the construction of a system of pile dikes, but it is contended that if these dikes could be built of such strength and in sufficient numbers, as to preserve the bank as permanently as revetment work, the first cost would be greater than that of revetment. As a matter of fact, however, it may be said from actual experience and history for years back, that no dike has ever been built that does not require constant attention and expenditure of money to preserve it. Revetment work leaves the bank line composed of straight lines and gentle curves, and offers no resistance to flow, but a dike is an obstruction placed in the channel, which is immediately attacked, more or less savagely, according to the velocity of the current; a scour of the river bed takes place at its end and eddies are formed above and below the structure, which are more destructive to the bank than a straight swift flow. So that, eliminating the deteriorating qualities of the materials of which the pile dike is built, its resistance to the natural flow of the current sets in motion forces that are not only destructive to the structure itself, but also to the bank both above and below its location. It is not to be understood from this that pile dikes should

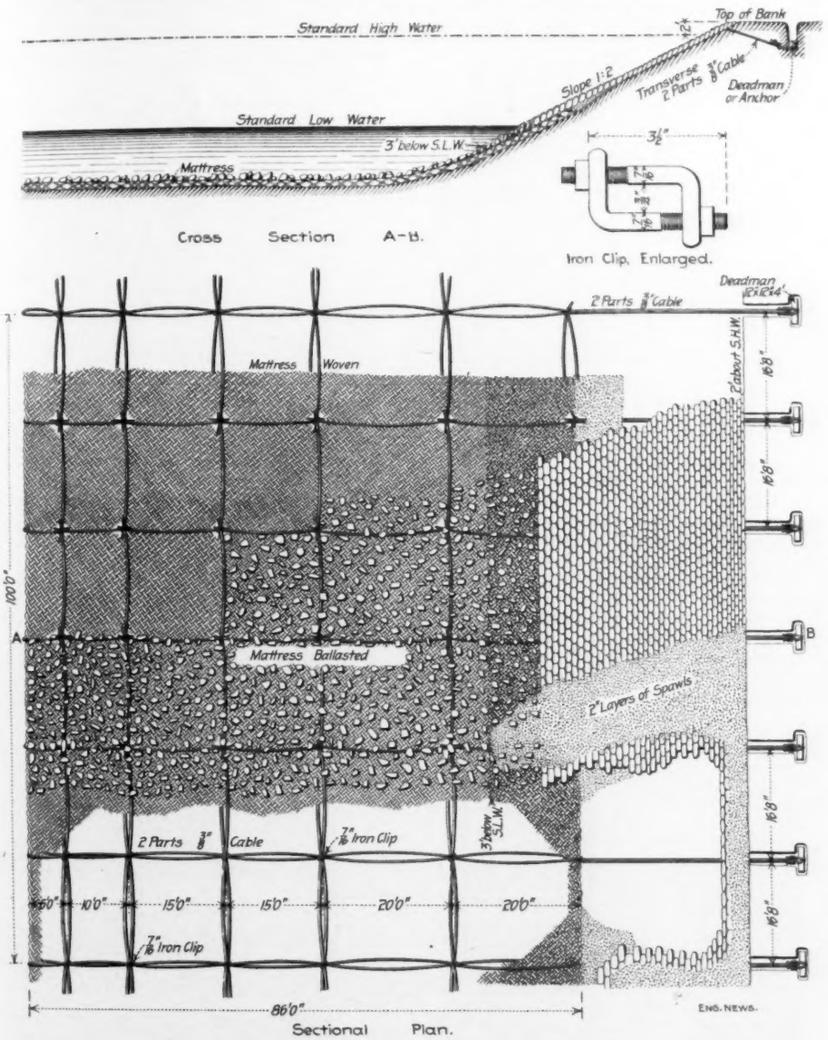


FIG. 2. DETAILS OF MATTRESS AND REVETMENT WORK; CHICAGO & ALTON RY.
H. F. Baldwin, M. Am. Soc. C. E., Chief Engineer. W. R. De Witt, Assistant Engineer.

never be built, for that plan is a very proper one where chutes are to be closed off, bends chorded or land formed, but it is claimed that for the mere preservation of the bank line, the revetment work as now used by the U. S. Government is the most economical and stable structure that up to this time has been put into practice.

There are other forms of work for bank protection, such as dikes made of fascines, composed

FIG. 4. WEAVING MATTRESS.

of brush and stone, or brush only; but while they may not be so expensive as pile structures, they have all of the defects and absolutely none of the stability. The continuous revetment protects every inch of the bank line, is practically permanent, and when his work is once completed, the builder has to look elsewhere for a job.

THE ASPHALT AND BITUMINOUS ROCK DEPOSITS OF THE UNITED STATES.

The following material relating to the asphalt and bituminous rock deposits of the United States is taken from a very full report upon this subject made by Mr. George H. Eldridge, and forming a part of the Twenty-second Annual Report of the U. S. Geological Survey.*

The author commences by classifying hydrocarbons and allied substances under the main heads of gaseous, bituminous, resinous, cereous and crystalline. He omits from this table the common terms "asphalt" and "bitumen;" omitting the first because this word is restricted by the best authorities to the solid forms of the purer bituminous, though industrially the word "asphalt" is unfortunately made to include almost every compound of bitumen with a foreign material, chief among the latter being sand and limestone. Bitumen is omitted, though its adjective, bituminous, is employed. Bitumen has been used for ages past to include the three varieties of hydrocarbon compounds known as petroleum, maltha, or mineral tar, and the solid substances included under the asphaltites, some of them often designated as "asphalt." The adjective bituminous, is here applied to a sandstone or other rock impregnated with bitumen; and if this bitumen is asphaltic, or has any of the characteristics of the so-called asphalts, the compound many be called "asphaltic sandstone," etc.

The classification, with a few modifications, is that of Prof. W. P. Blake, and is the most satisfactory thus far presented. It is shown in the accompanying tables.

The author gives these tables with the caution that were the chemical and other relations of the hydrocarbons, in Table I., worked out, they would doubtless show the utmost complexity; for complexity exists in the substances themselves. The two or more components into which each may be divided may be subdivided into series of hydrocarbons, in many instances of great extent.

The distribution of asphalts and bituminous rocks in the United States is far wider than most suppose. The asphaltites are found in West Virginia, Indian Territory, Colorado and Utah; bituminous limestone in Kentucky, Missouri, Indian Territory, Texas, Utah and California; earthy bitumen of great purity occurs as veins in California; brea, possibly occurs in all petroleum areas, but is only reported in Indian Territory, Wyoming, California, and in small bodies in Montana.

The origin of the hydrocarbons, as such and in the bituminous compounds, is traced by the writer to petroleum. This is a natural inference from chemical relations; and the wide variations in composition and physical aspect of the bitumens may be due to the fact that important differences are found in the petroleums themselves. The variation in the asphaltites may be more marked; for in the passage from petroleum to its derivations the process may have stopped at any point, with a corresponding development of physical and chemical distinctions. The asphaltic earths, and some solid bitumens, are frequently associated with active petroleum springs, or occur in regions known as oil-producing. The writer regards sandstones as only storage reservoirs for the oil; while limestone may have been the locus of origin as well as of storage. In California, investigation has shown that a reservoir may have been filled from an overlying, as well as an underlying formation; deposits of oil resting on granite are cited in corroboration. The asphaltites are closely associated hydrocarbons—like ozocerite, for example, can hardly have been derived otherwise than by the draining of petroleum pools, or strata richly saturated with oil. The absence of every trace of petroleum in the sandstones enclosing gilsonite, and the presence of the latter in the underlying Green River shales, indicates the latter series as the one-time source of the oil, which on entering the fissures was converted into the asphaltites. In the filling of all reservoirs the writer was struck with the almost inevitable slowness of the process, and the vastness of the area of fine-grained sediment that must have been drained to yield the supply absorbed. In the case of the asphaltites the hardening must have been very gradual, the material passing through a viscous stage, with fragments of rock dropping from the walls into the bitumen and supported by it.

TABLE I.—Classification of Natural Hydrocarbons.

Gaseous			Marsh gas.
			Natural gas.
Bituminous	Fluid		Naphtha.
			Petroleum.
	Viscous (malthite)		Maltha.
			Mineral tar.
			Brea.
			Chapapote.
	Elastic		Elaterite (mineral caoutchouc).
			Wurtzilite.
	Solid	Asphaltic	Albertite.
			Impsonite.
			Grahamite.
			Nigrite.
			Uintaite (gilsonite).
		Coal	Lignite.
			Bituminous coal.
			Semi-bituminous coal.
			Anthracite coal.
Resinous			Succinite (amber).
			Copalite.
			Ambrite, etc.
Cereous			Ozocerite.
			Hatchetite, etc.
Crystalline			Fichtelite.
			Hartite, etc.

TABLE II.—Grouping of Natural and Artificial Bituminous Compounds.

Natural	Mixed with limestone (asphaltic limestone)	Seyssel, Val de Travers, Lobsan, Illinois, Utah, etc.
	Mixed with silica and sand (asphaltic)	California, Kentucky, Utah, etc.
	Mixed with earthy matter (asphaltic)	Trinidad, Cuba, California, Utah.
	Bituminous schists	Canada, California, Kentucky, Virginia, etc.
	Fluid	Thick oils from distilled petroleum, "residuum."
Artificial	Viscous	Gas tar.
		Pitch.
		Refined Trinidad asphaltic earth.
	Solid	Mastic of asphaltite.
		Gritted asphaltic mastic.
		Paving compounds.

FIG. 5. SINKING MATTRESS WITH STONE.

*"The Asphalt and Bituminous Rock Deposits of the United States." By George H. Eldridge, U. S. Geological Survey, Washington, D. C. 7¾ × 11¾ ins.; pp. 211-464; illustrated.

The report takes up the location, character, detailed geology and statistics of these asphalts and bituminous rocks in the United States, state by state. This detail is illustrated by maps, geological sections and photographs; and while interesting and very valuable, the space available forbids any intelligent extracts. The reader must be referred to the document itself.

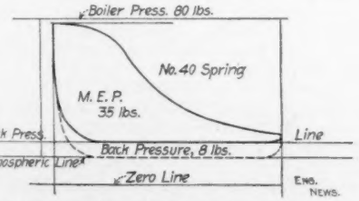
LOSSES FROM BACK PRESSURE IN EXHAUST STEAM HEATING SYSTEMS.

By Robert L. Gifford, C. E.*

Utilization of exhaust steam in heating is economy, and heating becomes a by-product of power production—provided that excessive back pressure is not put on the engines supplying the exhaust.

During the recent cold weather the writer had occasion to note the back pressure conditions in several exhaust heating plants, and has been impressed with the fact that due attention is not paid to the heavy loss in power due to engines operating against high back pressures. In buildings or factories which contain large power plants and relatively small amount of heating surface in proportion to the power units, the supposed economy from the use of the exhaust may be entirely offset by the loss in power developed, due to excessive back pressure.

Such a condition is unusual, but there are plants operating with 7 and 8 lbs. back pressure in severe weather, resulting from restricted mains and piping in the heating system, where true economy would be secured by exhausting into the atmosphere, and using live steam in the heating system.



Typical Indicator Card Showing Loss of Power from Back Pressure.

This extreme condition never obtains in a large office building, as the steam required for heating is greater than the equivalent steam lost by back pressure at the engines, but a loss is there just the same, and true economy can only be secured by eliminating the back pressure. In an office building recently examined, the heating system was a single pipe system with scanty risers, and the back pressure on generator engines, elevator and house pumps was 8 lbs. About 300 HP. was developed at 80 lbs. boiler pressure, or about 35 lbs. M. E. P. in cylinders, at one-fourth cut-off. The conditions existing are shown graphically in the indicator card, and the power which would have been developed in absence of the 8 lbs. back pressure, is 27.35::300:X, or 389 HP, shown by dotted area on card; so that the loss due to back pressure was 89 HP., or the proportion of 8 to 35, or 23% loss in power.

The equivalent live steam, if used direct in a heating system, would have heated a 6-story building 75 ft. × 100 ft. in severe weather. In other words, had the building been a 6-story building, 75 ft. × 100 ft., the same steam consumption would have heated the building with live steam, and developed 300 HP. while exhausting into the atmosphere, and no economy would have resulted from the use of the exhaust.

When, however, exhaust steam can be circulated through the heating system at or near atmospheric pressue, and back pressure thus eliminated, the heating becomes truly a by-product, and in addition the economy of a condensing plant can be partially realized during the heating season, as the radiation from heating coils condenses the exhaust steam, and serves the same purpose as artificial cooling in condenser plants.

There are many single-return exhaust systems, with scanty risers and superfluous bends in piping which require 7 and 8 lbs. pressure for circulation in severe weather, and, as a great majority of these systems do not have an overhead supply, trouble results from the steam having to force its way up against the descending volume of condensation. In addition to increasing the pressure, this produces water-hammer, and the shock and pounding is liable to cause leaks in piping.

With old plants now in operation it is usually impracticable to change the size of piping, so that the only remedy is to equip the system with a vacuum return, which will eliminate the back pressure, and at the same time increase the capacity of the system by relieving the risers of the water of condensation, thus leaving the full capacity of the risers free for the supply of steam, which, in the latitudes of New York and Chicago is a very important matter, as a majority of one-pipe up-riser systems are seriously crippled in severe weather by the rapid condensation which fills the lower ends of the risers just at a time when the full heating capacity of the system is required.

An effective vacuum system for relieving these water-logged risers can be designed without the use of patented vacuum equipment.

In new installations these troubles can be avoided, and back pressure kept down to reasonable limits by proper designing and ample sizes of piping. It is poor economy to cut down first cost of installation of any equipment where cost of maintenance and operation is so largely increased thereby, to say nothing of the added comfort of occupants which is secured through the refinements in operation of a proper heating system.

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FIG. 6. PAVING SLOPE ABOVE MATTRESS.

THE THAMES FOOTWAY TUNNEL, AT GREENWICH.

This footway tunnel under the River Thames is now nearing completion, and is described in a late paper presented to the Institution of Civil Engineers by Mr. W. C. Copperthwaite, M. Inst. C. E.

This tunnel is intended to replace the steam ferry between Greenwich and the Isle of Dogs, and is being built by the London County Council. It was commenced in June, 1899. The subway consists of a cast-iron tunnel, 12 ft. 9 ins. diameter, connecting two shafts 43 ft. external diameter and 1,217 ft. apart; with access provided by lifts and circular stairways.

From each shaft the tunnel dips towards the center of the river with a gradient of 1 in 15, provision being made for allowing the dredging of a channel in the river 500 ft. wide and 48 ft. deep at high water. The shaft-caissons were 35 ft. in internal diameter, with an outer steel skin, and the 4-ft. annular space between these skins was filled with 6 to 1 Portland cement concrete. These caissons were vertical on the outside and sunk by the use of compressed air. During sinking the opening in each caisson intended for the tunnel was closed by steel plates.

The cast-iron tunnel lining was that ordinarily used, with some improvements to secure watertight joints. All bolt-holes were made with a small portion beveled off, and lead washers were put under the bolts, so that the lead filled the bevel edges of the bolt holes when the nuts were set up. In the joints between castings soft lead wire was hammered before calking.

The shield used in the Greenwich tunnel was 14½ ft. long and 13 ft. diameter externally; the cutting edge was made in 13 segments, and immediately behind the cutting edge was a circular-built box-girder. The rate of progress was rapid; as much as 10 ft. per working day having been made over all the tunnel, except for a short length in gravel on the Greenwich side. As the result of experiments in passing the air supply over caustic soda some of the carbonic acid was removed from the air in the tunnel.

THE FLYING SHEAR.*

By E. V. Edwards.†

In the engineering office of a past president of this society the question of cutting metal bars while in motion had been so carefully discussed that in 1892 a carte blanche order was accepted for a mill and equipment which should accomplish unprecedented results. The problem was to take 2½-ton ingots after they had been worked down on a 34-in. reversing mill to a long bloom having a cross section of 4 ins. × 5 ins., crop the first end of the piece which was then some 80 ft. in length, roll the entire ingot to a section 1½ ins. square, cut it up into any desired lengths from 15 to 30 ft., cool the severed billets and load them on cars. The stipulated crop-waste was one crop and one short from the 4-in. × 5-in. bloom. This meant rolling a 1½-in. square section over 600 ft. long and cutting it into 20 or more billets 30 ft. long, or shorter if desired.

The ground available was a triangular space scarcely 100 ft. on its longest side. Within this 100 ft. must be placed the connecting drawbridge table, the preliminary shear, the mill, the finishing shear, and the elevator for taking the severed billets to a high overhead conveyor, which should carry them to a distant elevated cooling bed, from which they would be loaded on cars, by gravity. These conditions, of course, called for a continuous mill and meant that the billets must be cut while in motion and close to the finishing pass.

The mill problem was interesting. The shear problem had in addition the exhilaration of pioneer work. The preliminary shear must be able to cut 4 ins. × 5 ins. hot steel, and to do this cutting while the bloom was either stationary or in motion. The shear used was a simple hydraulic shear trunnioned at the base to permit the knives to travel with the moving bloom during the instant of cutting.

The shear at the finishing end of the mill required much study. The shear knives must move horizontally as fast as or a little faster than the billet. This horizontal movement must be entirely independent of the billet. The cutting must be done in a small fraction of a second; a clear passage must be made instantly for the oncoming billet; the shear must complete its cycle and be back in its original position ready for the second cut, all in less than one second. The moving parts could not be made light, as the shear was to cut not only 1½-in. square, but any size up to 9 sq. ins. section, and the steel was liable to be high carbon and quite cool.

From many designs, that shown in Fig. 1 was chosen. Fig. 2 shows the elementary idea more clearly. The two

*Abstract of paper presented at the Boston meeting (May, 1902) of the American Society of Mechanical Engineers.

†Worcester, Mass.

most noticeable features of this design are, first, the cutting is incidental to the forward movement of the shear; second, one knife is hinged in such a manner as to swing freely out of the way of the oncoming billet as soon as the cut is completed. The cutting stroke is made by a hydraulic cylinder in connection with a steam intensifier.

As the first end of the advancing billet passes between the knives to crop the first end, an attendant presses a small lever. This releases the steam pilot valve, which in turn opens the main steam valve. The steam piston rises, forcing the confined water into the shear operating cylinder. The stroke of the cylinder is 24 ins. Of this 24-in. stroke, about 8 ins. are used in picking up the clearance and in getting the shear knives to traveling as

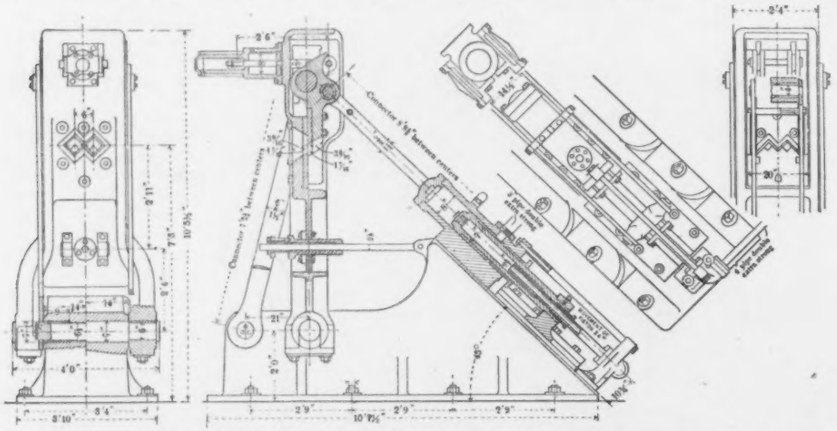


FIG. 1. SECTIONAL ELEVATION OF ORIGINAL FLYING SHEAR BUILT FOR JONES & LAUGHLIN, PITTSBURG, PA.

fast as the billet. About 8-in. stroke is used for the actual cutting, and the remaining 8 ins. are used for clearance and for stopping the moving parts. The instant the shear begins to slow, the oncoming billet quietly pushes the hinged upper knife out of its path. Automatic link connections reverse the steam valves, and the return stroke is made by means of a small plunger under constant hydraulic pressure. The upper knife swings back to its original position while the return stroke is being made. The swinging knife is so heavy that a dash pot is used to prevent slamming.

After cropping the first end, all subsequent cuts are made automatically by the advancing end of the billet passing under a trigger placed 30 ft. from the shear, or closer if shorter lengths are wanted. The first machine was a complete success, and has been in constant use about nine years, with only ordinary repairs.

The next shear of this type was a small one, for cropping the first end of bars while running between consecutive passes of a continuous mill and for cutting and diverting the bar in case of a cobble. (See Fig. 3.) This is operated by a boy, who snaps the trigger of the small

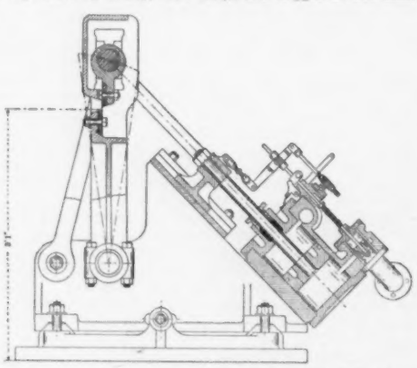


Fig. 2. Sectional Elevation of Small Flying Shear.

piston valve of the operating steam cylinder. Quite a number of these have been installed, and they have become an important adjunct in rod, hoop and merchant mills. The original shear of this size has been at work continuously for some seven years.

The billet mill and shear gave Jones & Laughlins such complete satisfaction that the Carnegie Steel Co. ordered a similar equipment to be used as an outlet for small billets from their 21-in. mills at Duquesne. To operate this shear, a direct-connected steam cylinder was used somewhat similar to the small shear which had given such good results. The success of this installation resulted in the Carnegie Co. placing an order for a second mill and shear for finishing the output of their new 40-in. mill at Duquesne. About the same time the National Steel Co. ordered a similar equipment for their "Ohio" plant at Youngstown. More recently the Republic Iron and Steel Co. have ordered five shears for their new plant in the same busy city. The shear at the "Ohio" plant is the fastest running billet shear as yet installed; it is regularly cutting 1½-in. steel billets at a rate of 2,000 tons per 24 hours, provided the mill is kept full.

Very high speed work calls for different treatment. In 1894 the Union Iron and Steel Co., of Youngstown, O., placed a blanket contract for equipment to roll cotton-tie from a billet weighing 225 lbs. (the common practice in rolling ties at that time was to use a billet weighing 15 lbs.). In this mill everything was without precedent, continuous furnace, continuous roll trains, continuous shearing and continuous cooling. It is needless to say that much trouble was experienced. Perhaps the most serious and expensive annoyance was the discouragement of the workmen by their doubting and pessimistic friends. In this mill it was necessary to cut hot cotton tie ⅞-in. in width by 5.100-in. in thickness, and to do this cutting while the hot tie was traveling at a speed of some 25 ft. per second. The cutting in itself did not give much trouble, neither did falling from the roof injure our traditional Irish friend. In both cases the trouble all came in the stopping.

Think of having come 150 hot, limber cotton ties, 11 ft. 6 ins. long, limp almost as wet tissue paper, shot out endwise in one minute with no clearance between the ends. The momentum would slide them over 20 to 40 ft. of rough iron floor. Let the least obstruction get in the way and a large pile of scrap was instantly made. These difficulties, however, were soon overcome, and the arrangements used gave excellent satisfaction for cotton-tie.

The shear used in shown in Fig. 3. The knives were carried on two conical drums geared together. In order to get long lengths without having large drums, small drums were used with the upper one carried in a hinged frame, the free end of this frame was supported through connecting rods by eccentrics on a shaft which was driven at one-half, one-third, or one-fourth of the number of the revolutions of the drum. By this means the knives did not quite meet, and consequently did not cut the thin tie except on multiple revolutions. By shifting the position of the knives on the cone, and by the use of change gears on the eccentric shaft, any length desired could be cut accurately.

For barrel hoop it appeared desirable to cool the hoop before allowing the severed strips to overlap, otherwise the hoop would look streaked and not have the beautiful blue finish acquired by uniform cooling with the exposure to the air. It was also desirable to be able to carry stocks in coils from which small orders could be shipped promptly, cut to any specified length. These conditions led to air-cooling the hoop by looping it out on an advancing apron and then reeling or coiling the hoop as it was delivered at the far end of the apron after it was sufficiently cool to have acquired and to hold its finish. These tightly wound coils were then either placed in stock or cut up at once on shears entirely apart from any interdependence with the rolling.

The leading feature of these shears is the simple method of getting rotary shears to cut long lengths without complication or large diameters. This was accomplished by making the pitch diameter of the upper and lower cutting heads, together with their gearing, of different diameters. For example: If the gears have the ratio of 3 to 2, it will be seen that the knives would come in opposition but once in 3 revolutions of the large head, or 2 revolutions of the small head; this allows the diameter of the cutting heads and gears to be reduced in the same proportion.

Cutting up material while in motion is not broadly new. We are all familiar with many appliances for this work, ranging from the old hay or feed cutter to that type of organization, the modern newspaper press. Cutting metal bars while in motion had been accomplished, for example, in rolling horse shoes and some other lines. Yet, considering the state of the art at that time, much credit is due Messrs. Jones & Laughlins for the firm confidence with which they installed an expensive and elaborate continuous mill and accessories while fully realizing that the success or failure of the whole equipment was entirely dependent on something so little demonstrated as the flying shear.

A PORTABLE CONCRETE-MIXING MACHINE OF THE CUBICAL-BOX TYPE.

While numerous types of concrete-mixing machines are in use, the cubical-box machine has always been regarded with favor by a large number of engineers, and is very extensively used for important works. One objection to this style of machine is the loss of time in dumping and charging. Ordinarily the charge is put in through a door which has to be bolted on, and when the concrete is mixed the box is turned up so that a man can unbolt the door; it is then turned down to discharge the concrete, part of which must generally be got out with a shovel, after which the box is again turned up to receive another charge. In the accompanying cut we illustrate a new form of concrete-mixing machine, which is believed to combine the advantages of the box type with

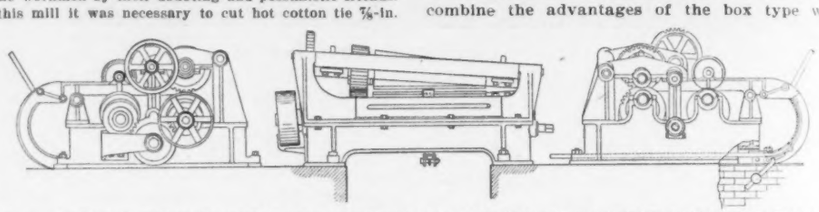


FIG. 3. CONICAL ROTARY SHEAR FOR CUTTING HOT COTTON TIE DIRECT FROM THE FINISHING PASS.

great rapidity of operation. Batch mixing is generally preferred to continuous mixing, and this machine has nearly the rapidity of a continuous mixer while retaining the advantages of the box mixer.

The box, A, is mounted on hollow trunnions, B B, at diagonally opposite corners, these trunnions revolving on rollers, C, carried on a rocker frame or cradle, D. This frame runs on guide wheels, L L, and has a rack under one of the curved bars and the frame is moved (to tilt the box) by a pinion gearing with this rack, as shown in Fig. 1. A bevel gear, E, drives a pinion, F, which revolves the box by means of a sprocket chain, G, passing around one of the trunnions. Above the small hopper, H, shown at the side, is a large measuring hopper, J (not shown in place), in which the proper proportions of materials for one batch are measured, while the previous batch is being mixed. This effects a material saving in time, for as soon as one batch is dumped the materials are all ready for another batch. When the machine is to be charged, the box is tilted to bring the two trunnions in a horizontal line, the trunnion at the left being then in line with the opening of the back of the small loading hopper, H. The gate of the measuring hopper is then opened, and the materials fall through the small hopper or chute into the box. Water is admitted at the same time, by the pipe, K. There are no deflectors inside, and the door at the discharge end is simply a hinged disk to prevent the materials from spattering. The box makes about 14 revolutions per minute, and two minutes is generally sufficient for mixing.

The box is then tilted to an angle of about 45° to discharge its contents, but a special feature of

the machine is that the box still continues to revolve while discharging, and as the front is vertical (as shown in Fig. 2), the concrete cannot lodge or remain in the box. To allow for the revolution of the box when at any angle, the bevel wheel, E, slides on a channel-shaped shaft carrying the sprocket pinion, F. This bevel gear and trunnion chain are driven continuously by the engine, while the pinion for tilting the rocker frame and box is thrown in and out of gear by a clutch as required. It is claimed that the box can be dumped and returned to the loading position in 10 seconds.

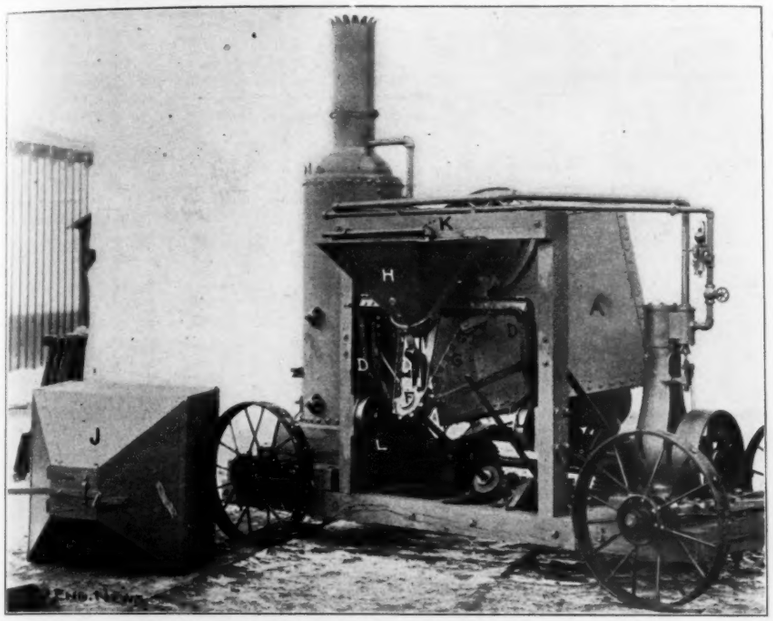


Fig. 1. Side View.

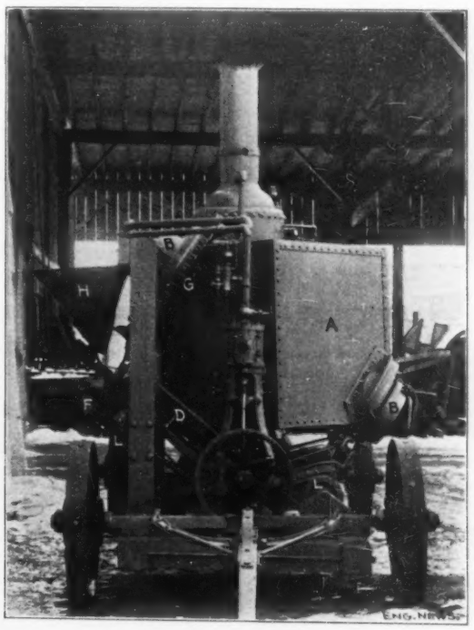


Fig. 2. Front View.

A PORTABLE CONCRETE MIXER OF THE CUBICAL BOX TYPE. Municipal Engineering and Contracting Co., Chicago, Makers.

The machine is portable, the engine, boiler, and mixer being all mounted on a timber frame carried by four broad-tired wheels. The weight is about 6,000 lbs.; it will be somewhat less if a gasoline engine is used, or still less if an electric motor is used, as for concreting street railway track, etc. The machine is made in three sizes, for batches of ½, 1 and 2 cu. yds. capacity, with engines of 7, 9, and 15 HP., respectively. It is now being used by Mr. D. J. McNichol, of Philadelphia, Pa., who has contracts for concrete sewer and reservoir work in that city. The machines are being introduced by the Municipal Engineering & Contracting Co., Manhattan Building, Chicago, Ill.

BOOK REVIEWS.

TABLES FOR OBTAINING HORIZONTAL DISTANCES AND DIFFERENCE OF LEVEL FROM STADIA READINGS.—Computed by Alfred Noble and Wm. T. Casgrain, U. S. Engineer Office, Milwaukee, Wis. New York: Engineering News Pub. Co. Cloth; 4½ × 7 ins.; pp. 47. $1.

The stadia reduction tables presented in this little book are doubtless the most complete ever made. The heights and distances are given to four places of decimals for every minute from 0° to 20°. An introduction gives full directions for the use of the tables, useful hints on stadia work, and an approved rod graduation with directions for making rods.

These tables were compiled by the authors many years ago and a small edition was printed for private circulation. That edition has long been out of print, however, and the numerous applications for it led the authors to prepare the present edition by which these valuable tables are for the first time made available to the profession generally.

THE BLOCK SYSTEM OF SIGNALING ON AMERICAN RAILROADS: The Methods and Appliances Used in Manual and Automatic Block Signaling; Also Descriptions of Hand-Operated and Power-Operated Interlocking Machines.—By Braman B. Adams. New York: The "Railroad Gazette." Cloth; 8vo.; pp. 266; illustrated. $2.

This book makes no claim to be a treatise on signaling in general, but consists mainly of descriptions of the signals, signal apparatus and rules governing block-signal operation on a number of individual American railways, with little criticism or comment. Different systems of manual, automatic and three-position signals are included. At the outset the author states that the term "block system" issued to designate any means of maintaining a fixed minimum interval of space between two trains traveling in the same direction on the same track; this explanation would exclude single-track block working, which is one of the most important considerations in this county, but it is evidently only a careless definition, as both single-track and double-track blocking are included in the book. Some of the apparatus is described in very minute detail. The part dealing with interlocking is somewhat disappointing, as it does not discuss the principles governing the design of interlocking plants, but mainly describes in detail the mechanism of certain manual, electric, pneumatic and electro-pneumatic interlocking machines. A list is given of about 60 railways with 26,600 miles or road operated on the block system, and 42 railways with 3,354 miles of road equipped with automatic block signals. The book is well written and very fully illustrated.

HYDRAULIC MOTORS AND TURBINES, for the Use of Engineers, Manufacturers and Students. By G. R. Bodmer, A. M. Inst. C. E. Third edition, revised and enlarged. New York: D. Van Nostrand Co., 23 Murray St. Cloth; 4¾ × 7¾ ins.; pp. 565; illustrated. $5.

The third edition of this work has been enlarged by the addition of two chapters, to note development in the governing mechanism and in the adaptation of well-known types of turbines to the driving of electric machinery. The main body of the work remains unchanged from the previous edition. Here, the general subject of turbines is first taken up, and this is followed by chapters on the general theory, losses of energy and design of reaction turbines; on impulse turbines; rules, formulas and numerical examples; on the measurement of flowing water; experiments with turbines, etc. As shown in the last two chapters, the adaptation of turbines to running electrical machinery tends to very high speed; and to obtain the uniform speed demanded in this work the governing mechanism has been much developed. Every effort is now made to keep the diameter of the wheel within the smallest practicable limits; and the inward, or mixed flow wheel is most in vogue—says the author, who proceeds to give in detail the reasons for the present practice

A PROPOSED GERMAN-AUSTRIAN TUNNEL is being discussed. It would pass from Garmisch to Flaurling, 11.16 miles; and the estimated cost is 40,000,000 kronen, or about $8,000,000. It pierces the Wetterstein Mountains, and the tunnel will be about 2,211 ft. above the sea, connecting Bavaria with the Austrian Tyrol.

A ST. PETERSBURG ELECTRIC RAILWAY concession has been secured by Mr. Murray A. Verner, of Pittsburg, Pa. This concession is for the construction of an electric line from the heart of the city to a suburb. The proposition of Mr. Verner and his associates to take over the entire surface railway system of St. Petersburg has not been accepted, but they hope to secure the greater concession in time. The latter proposition involved the formation of a company with $50,000,000 capital.

A CAPE HATTERAS LIGHT-HOUSE has been designed by Capt. A. F. Eells, of Boston, and a bill embodying this plan is before Congress. The bill provides for a location in not less than 30 ft. of water; the light-house is to have a concrete base sunk at least 15 ft. into the bottom, this base to be 70 ft. diameter at bottom, 30 ft. at the water line, and not less than 27 ft. above the sea. Above this is to be a circular steel structure for the keeper's quarters; and above that a steel tower or mast containing a circular stairway, with the light 200 ft. above the sea. The bill appropriates $30,000 for this light-house, and provides that after two years of actual operation a further sum of $275,000 be paid to Captain Eells. No further details are given, and the plan does not inspire confidence in success.

A FAST RAILWAY RUN was made on the Wabash R. R. between Montpelier, Ohio, and Detroit, Mich., on May 25. The train was a special running from Indianapolis to Detroit. The following is an abstract of a report of the run, kindly furnished us by Mr. C. S. Crane, General Passenger Agent of the Wabash R. R.:

German Skat Society Special, May 25. Engine 611, Atlantic type, Richmond. Wt., 281,600 lbs.; Wt. on drivers, 81,000 lbs.; cylinders, 19 × 26 ins.; drivers, 79 ins. Four cars.

Distance between.	Stations.	Time between, min. sec.	Speed.
7.1	Montpelier	8.30	50.1
4.1	Kunkle	3.18	74.7
6.2	Alvordton Jc.	5.17	70.2
6.3	Munson	5.17	71.4
3.0	N. Morenci	2.33	70.5
4.6	Seneca	3.53	71.0
6.8	Sand Creek	6.02	67.8
6.4	Adrian	5.37	68.2
5.5	Holloway	4.38	71.2
4.8	Britton	4.05	70.7
4.8	Cone	4.15	67.9
5.8	Milan	6.05	68.7
2.8	Whittaker	2.27	68.8
5.1	Willis	4.23	69.7
4.6	Belleville	3.50	72.2
6.6	Romulus	5.17	75.0
6.8	Hand	4.50	84.4
1.4	Oakwood	2.23	35.1
4.2	Delray	6.20	39.8
...	Detroit	....	....
97 miles.		88.09	66.2

If the first station distance and the last two be omitted, this record shows a long-distance average, Kunkle to Oakwood, distance, 84.2 miles; time, 70 min. 47 sec.; speed, 71.4 miles per hour.

CHICAGO STREET RAILWAYS and street railway traffic conditions are to be investigated on behalf of the Local Transportation Committee of the City Council. The present facilities are admitted to be inadequate, and the Council is of opinion that in consequence of the dispute over franchise extensions the companies are not doing what they could and should do in order to improve the facilities. The committee has appointed Mr. B. J. Arnold, M. Am. Inst. Elec. Engrs., to investigate the technical matters involved. These will include the valuation of the present lines (including tracks and power plants), the

cost of reconstruction, the best methods of construction and equipment, and the possibilities of underground railway systems. The questions of wages of employees, the financial conditions of the companies, the cost of operating the present lines, and the means of reducing the cost of operation will also be considered.

AN EXTENSION OF THE FILTER BEDS of the waterworks of Lawrence, Mass., and a roof over the present filters have been recommended by the State Board of Health. The local water board proposed to divide the present single bed of 2½ acres area into three beds by building cross walls, but the State Board of Health believes that this would add but slightly to the yield of the filter. The proposed addition would have an area of about two acres and would consist of two beds. Mr. Michael Collins is superintendent of the Lawrence water-works.

A SUBURBAN TERMINAL STATION is to be built by the Chicago & Northwestern Ry. as an annex to its main terminal station at Wells St., Chicago. The strip of land between the main station and the river was acquired some time ago, and six additional tracks have been laid, the platforms of which will have umbrella or shelter roofs. The new building at the end of these tracks will be 160 × 58 ft., with baggage room, etc., on the track level and one large waiting room on the upper floor, level with the street.

THREE-CYLINDER SUBURBAN TANK LOCOMOTIVES are reported as being built by the Great Eastern Ry., of England, for the express purpose of obtaining rapid acceleration on the busy city lines entering London. One of these suburban routes has 14 stops in 11 miles. These new engines have three high-pressure cylinders 18½ × 24 ins., and ten driving wheels 54 ins. diameter, on a wheelbase of 19 ft. 8 ins. The total weight will be about 60 tons, including 2,000 gallons of water in the side tanks and 4 tons of coal in the bunker behind the cab. The boiler is 5 ft. 3 ins. diameter, with 384 tubes, 1¾ ins. diameter and 14 ft. 9 ins. long. The total heating surface is 2,770 sq. ft., with 2,639 sq. ft. in the tubes. It is expected that such an engine with a heavy train will attain a speed of 30 miles an hour in 30 seconds.

OILING ROADS AND RAILWAYS, for the purpose of laying the dust may be practiced in the neighborhood of Marion, Ind. The authorities have put a stop to the pollution of streams by the refuse oil escaping from the oil wells, and a committee has been appointed by the oil operators to devise means for disposing of this refuse. This committee has in the first place recommended the construction of oil-traps or tanks to intercept the waste; and a sub-committee will confer with the city council, the county commissioners, and the officers of the steam and electric railways and endeavor to interest them in the use of the oil for sprinkling the streets, roads and tracks.

THE STATISTICS OF GUN-FIRE AT MANILA AND Santiago are included in a late naval report. At Manila six U. S. men of war discharged 5,818 shot of all calibers, aggregating in weight 66.9 tons and costing $50,045. At Santiago seven much heavier vessels discharged 9,474 shot, weighing 114.3 tons and costing $84,406. At the latter battle there were 124 hits of all calibers out of 9,474 shots.

MANUFACTURERS' MATERIALS, says the U. S. Treasury Bureau of Statistics, formed one-half of the importations of April last, and over 10% of the total importations in the ten months ending with April. The export of manufactures in April formed 36.54% of total exports, and 28.55% of the total for the same ten months; they formed 27.40% of the preceding corresponding ten months. The total value of the import of manufacturers' materials in the ten months ending with April, 1902, is $348,657,061, as compared with $280,801,407 for the corresponding period of last year. Exports of manufactures are nearly overtaking those of last year; there was a gain of about $4,500,000 in April over April, 1901, and for the ten months the total value of exports only falls $5,486,814 below the corresponding months of last year.

A YEAR'S PRODUCTION OF THE UNITED STATES STEEL CORPORATION.

At the last meeting of the Board of Directors of the U. S. Steel Corporation, President Schwab presented a report for the year ending March 31, 1902. This report gave statistics of the iron and steel production of the year in various countries, and details of the operation of the company he represented. These statistics are briefly as follows:

The total amount of iron ore mined by the company in the year was 13,326,705 tons, all from the Michigan iron deposits. The entire production of steel for the year 1901 was: For the United States, 13,369,613 tons; for Germany, 6,394,222 tons; for Great Britain, 4,850,000 tons, and for France only 1,465,071 tons. The company produced 7,152,121 tons of furnace product, including pig-iron, spiegel and ferro manganese; this is 45% of the total production of the United States for the year, which was 15,878,354 tons. In the same period Great Britain produced 8,959,691 tons, Germany 8,520,390 tons, and France 2,699,494 tons of pig-iron and spiegel. The U. S. Steel Corporation's ingot production was 9,034,580 tons, or 67% of the total product for the United States. Of this amount 6,262,202 tons were Bessemer and 2,772,378 tons were open-hearth steel.

The following table shows the amount of the various finished products manufactured by the company:

	Tons.
Rails	1,675,628
Blooms, billets and slabs (for shipment)	2,481,227
Plates	742,508
Merchant steel, shapes, bars, hoops, and bars	1,236,343
Sheets	415,299
Tin plate	404,746
Wire and wire products	1,078,838
Tubes and pipes	693,655
Axles and forgings	90,659
Angle bars and joints	127,582
Structural work, (bridge company)	489,506
Miscellaneous	50,877
Total	9,486,868

The amount of coke manufactured was 9,079,142 tons.

During the year the steel manufacturing properties made shipments of 10,023,837 tons, including those between the companies themselves. The manufacturing cost of these products was $315,662,881, and the selling value was $410,643,625, showing a profit of $94,980,744. The total coke shipments—including rehandling, were 10,970,768 tons, manufactured at a cost of 12,453,346, and having a selling value of $18,936,301; the profit shown is $6,482,955. The gross earnings of the transportation companies was $29,511,012; operating expenses and taxes, $164,431,006; leaving net earnings of $13,080,006. The outlay for repairs, maintenance and extraordinary renewals was divided as follows:

Steel-making properties	$19,208,335
Coke properties	881,763
Transportation properties	4,451,590
Total	$24,541,688

Exclusive of its own railway and steamship lines the company paid out $54,147,567 for freight charges; and to its 158,263 employes the company paid $112,829,198 in wages.

MECHANICAL STOKERS FOR LOCOMOTIVES.*

By Fred. H. Colvin,† M. Am. Soc. M. E.

1. The rapid growth in the size of locomotives and the consequent increased consumption of fuel per hour have brought many of our railroads face to face with the problem of securing men to fire them satisfactorily, for the fireman has not increased in size and capacity as has the locomotive. The question of economy in coal consumption is secondary to that of keeping the steam pressure at or near the popping point in order to secure the maximum work from the engine.

The conditions of locomotive practice are so different from those presented in the case of stokers for stationary boilers that they have seemed almost insurmountable, although much time and thought have been spent on them. These difficulties are not confined to the mechanical problem, for the selling of the locomotive stoker is an entirely different proposition from that in the stationary field. In the latter case it is an easy matter to show a marked reduction in labor cost, and this saving seems to appeal to buyers more than any other. In the case of the locomotive stoker there can be no reduction in labor cost, excepting in a few rare cases where two firemen are employed. This takes the cost of labor entirely out of the field, as it is not advisable to employ unskilled men on the locomotive equipped with a stoker, for in the event of the possible failure of the machine the engine must be fired by hand until the end of the run. It is also necessary to train engineers, and the only practical way of doing this seems to be by having firemen work with engineers as at present.

2. The practical advantages of the locomotive stoker can, perhaps, be summed up as follows:

(1) Increased work from the locomotive, due to maintaining a maximum working steam pressure under all conditions of service; (2) doing away with the necessity of constantly opening the fire door and admitting large quantities of cold air into the fire box, which opening tends to retard combustion and also has an injurious effect on the flue sheet; (3) even distribution of coal over the whole of the grate, obviating thin spots through which cold air may be admitted with results as injurious as when coming through the door, or even more so; (4) marked decrease in black smoke, due to the constant and steady firing according to the demands of the boiler; (5) economy of coal consumption, resulting from the steady firing above referred to.

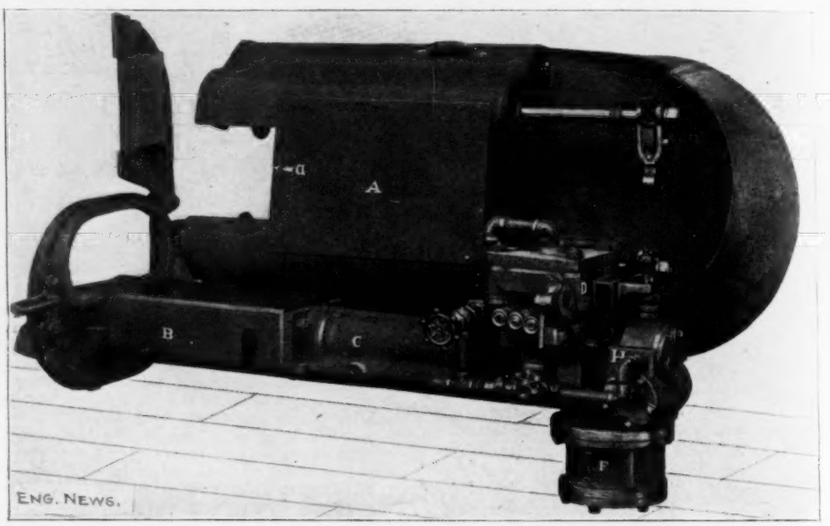


FIG. 1. MECHANICAL STOKER FOR LOCOMOTIVES. VIEW OF LEFT SIDE WITH HOPPER THROWN UP. John W. Kincaid, Cincinnati, O., Inventor.

3. As the only stoker for locomotive use of which I know is the one invented by Mr. John W. Kincaid, of Cincinnati, O., formerly an engineer on the Chesapeake & Ohio R. R., my paper will necessarily be confined to this machine and its work. Starting with the idea of producing a mechanical stoker which should take the place of hand firing, and realizing the difficulty of introducing or even experimenting with a stoker which would necessitate any radical change in the locomotive, Mr. Kincaid designed his stoker to be attached in place of the fire door. It will be noticed that it is a mechanical but not an automatic stoker, as the experience of the practical engineer showed that it was not feasible to attempt automatic stoking. While it is possible that ingenious mechanism might be devised which would regulate the amount of coal fired by the steam pressure in the boiler, it would greatly complicate matters, and hardly be as effective as though under control of a skilled fireman. There are many cases, such as preparing for a hard pull up hill, where the fireman will anticipate the demand on the boiler and prepare for it, while an automatic device must follow the demand instead of anticipating it.

The Kincaid stoker is fastened to the fire door opening, as will be seen from the illustrations, Figs. 1, 2 and 3, and consists of the hopper A, ram body B, ram cylinder

*A paper read at the Boston meeting of the American Society of Mechanical Engineers.

†Ed. "Locomotive Engineering," 174 Broadway, New York.

C, steam chest D, door frame E, conveyer cylinder F, its valve chest H, and the ram b. The conveying screws are actuated by the piston in cylinder F, which travels up and down and operates the screws by the ratchets shown, Fig. 1. The amount of coal fed forward to the ram can be varied by regulating the amount of steam by a globe valve near valve chest H, and it can also be reduced one-half by throwing one of the screws out of gear.

4. A globe valve admits steam to the valve chest of the ram. The motion of this ram is controlled by an ingenious valve, which gives three different strokes in regular order. The first stroke takes a full charge of steam and throws the coal to the front end of the fire box; next comes a medium stroke which takes care of the middle portion, and, lastly, a stroke which hardly does more than

hour, which is not likely to be called for in any practice or with any grate area which could be supplied by this machine.

It may be interesting to note that on the return trip of this locomotive it was fired by hand, and in spite of all the regular fireman could do, he lost 50 lbs. of steam in the first 12 miles. On the day previous this same fireman had no difficulty in keeping up steam almost to the popping point all the way up the worst hills on the division. This is self-evident proof that the stoker enables the maximum work to be obtained from the engine. On this occasion, and in almost every case where the stoker has been tried experimentally, it is simply fitted to the fire door and the back end braced up with a block of wood, or possibly a false deck is put on the engine. This was the case on the large locomotive referred to, and the fireman was obliged to shovel every pound of the coal into the hopper, which was thus at an inconvenient height, but in spite of this he told me that it was the easiest trip he had ever fired, as he was not subjected to the intense heat of the fire box at every shovelful. Only those who have stood before the open door of a locomotive fire box on one of these large engines hauling its full tonnage behind it can appreciate the ordeal to which the fireman is subjected almost constantly.

with one of the first machines. A defective casting gave way when they were running at full speed, and the fireman disconnected the stoker, swung it out of the way, and commenced firing by hand, without delaying him an instant or even causing him to ease up on the throttle.

9. I regret being unable to present any data as to the exact performance of these stokers, such as fuel economy, prevention of smoke, prevention of leaky flues, and increase in tonnage, due to their use. I can, however, testify to the practical working of the device from actual experience, and am informed by Mr. W. S. Morris, Superintendent of the Chesapeake & Ohio R. R., and other officials, that there is a marked advantage over hand firing. Some of the reports have credited it with a saving of 10 or 20% in fuel, but this is an estimate and not the result of careful test. It seems, however, that there should be no question as to some saving due to constant, regular firing.

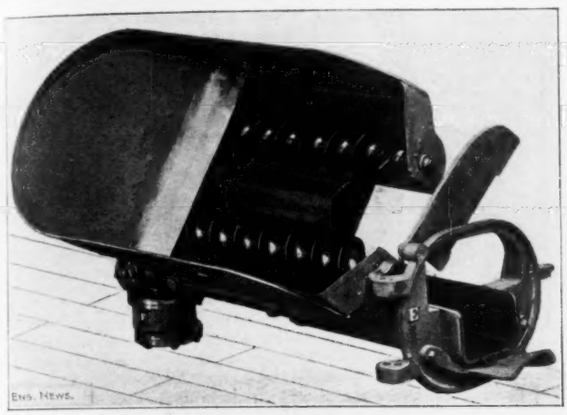


FIG. 2. VIEW OF STOKER READY TO ATTACH, SHOWING RAM, B., DOOR CASTING, E., AND DEFLECTOR PLATE.

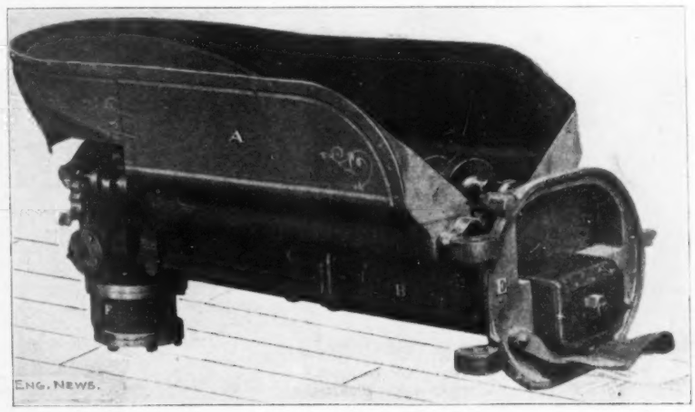


FIG. 3. TOP VIEW OF STOKER, SHOWING CONVEYING SCREWS AND AUXILIARY FIRE-DOOR.

push the coal over the deflector plate, which is shown bolted to B.

It is sometimes asked how this action distributes the coal across the fire box, but the explanation is not difficult when we note that the exhaust from the ram cylinder passes along under the ram and goes over the deflector. It is an ingenious arrangement, and required considerable experimenting to secure the right shape for this plate. Mr. Kincaid tells me that during his experimenting he found certain shapes of deflector plates which would throw nearly all the coal along the sides of the box, and other shapes which would pile up in the back corner. Any one familiar with the intense draught in a locomotive fire box would naturally credit this with a tendency to assist in the distribution, but I am informed that one of the first machines gave equally good results in a small electric light plant, where the draught was due only to a chimney.

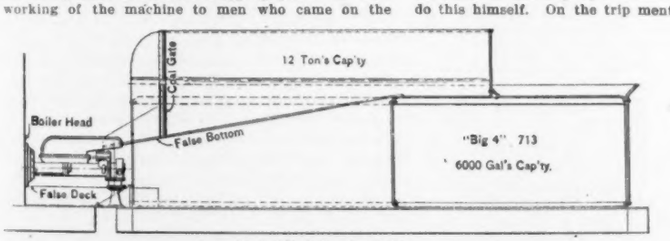
5. That the distribution is practically perfect is proved by the fact that one of these machines has successfully fired several of the largest engines on the Chesapeake & Ohio R. R. in which the fire box was 41 ins. wide and 11 ft. long. It was my privilege to spend a day on one of these locomotives a little over a year ago, and in a nine-hour run the hook was used but three times. It is probable that even this would have been unnecessary but for the firing done at various stopping points to show the working of the machine to men who came on the

7. The line drawing, Fig. 4, shows how a standard tank can be modified so that the coal will be fed into the hopper by gravity, and the fireman will have nothing to do but run the stoker and perhaps assist the coal occasionally with a small hand rake. In most cases, however, the jar of the engine will do all the feeding that is required. Fig. 5 shows a conveyor fitted to a standard tank. It is evidently better, however, to have the coal so that it will feed by gravity, and there is no objection to placing it well forward, as is done on the Vanderbilt tender.

8. It apparently handles any kind of fuel from anthracite to lignite, and ranging from lump coal to slack. It is advisable, however, to have the coal broken up to approximately uniform size, the same as in hand firing. On some roads this is done by machine before the coal is delivered to the engine, but most roads let the fireman do this himself. On the trip mentioned the fireman kept

10. Although primarily designed for a locomotive stoker, it is admirably adapted for marine work with the Scotch boiler. The fact of requiring no special setting, but being attachable to almost any boiler without alteration, is sure to appeal to the man who pays the bills, as in case it should not meet all the requirements, there is no expense or delay in taking out the device and substituting those formerly used.

Up to the present time the stoker has been applied to what is known as the narrow fire box locomotive, but it



Standard Tank Showing Modified Coal Bin and False Deck

FIG. 4. TENDER ARRANGED TO FEED COAL TO STOKER BY GRAVITY.

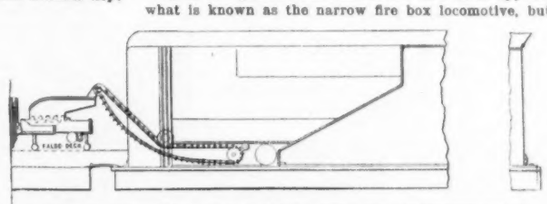


FIG. 5. TENDER WITH COAL FED TO STOKER BY A CONVEYOR.

engine. This rather clogged the fire and necessitated opening it up with the hook.

6. As an illustration of the range of capacity of this machine, it is interesting to note that the same stoker which fired the engine just referred to in my trip from Hinton, W. Va., over the mountains to Clifton Forge, Va., had been previously used on one of the lightest passenger engines on the division. Climbing some of the hardest grades over the mountains, the stoker was speeded up to 18 strokes per minute; and as the average charge was 5 or 6 lbs., this gave from 90 to 108 lbs. per minute, or from 5,400 to 6,480 lbs. of coal per hour. The machine, however, has been run experimentally as high as 28 strokes per minute, and can, if necessary, throw a 10-lb. charge at each stroke. This would give 16,800 lbs. per

a small hammer ready, and simply cracked the large lumps. If, however, a lump larger than the size of the ram should get into the hopper and be caught by the ram, it would lift the auxiliary fire door, which has an angle apron or lip for this purpose. This door is large enough to open for examination of the fire from time to time, or for using the hook if necessary, and, in fact, is as large as the opening of some of the fire doors used on a few of the Western mountain roads. With the hopper tipped back as shown, the locomotive could be fired by hand through this opening, but it is not necessary, as it is a simple matter to disconnect the steam pipe and swing the whole stoker to one side or even unhook it entirely. One of the engineers of the famous "F. F. V." train on the Chesapeake & Ohio R. R. told me of his experience

requires simply a modification in design, and probably a little experimenting into the bargain, to adapt it for wider boxes. In the so-called Wooten fire box, which in a few extreme cases is 9 ft. 6 ins. wide, it would probably require two machines, one for each floor. But in view of the fact that the extremely large grate is not well adapted to burning bituminous coal, and that within a few years this is likely to be the only fuel for locomotives, this can hardly be called much of an obstacle.

Another locomotive stoker has been submitted to me recently, on the plan of one of the under-feed stationary stokers, but as it necessitates extensive alterations in the fire box before applying, I do not see how it is to make much headway against a device like the Kincaid, which can be attached with practically no change or expense.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

A new method of protecting structural steel exposed to locomotive gases was briefly referred to in a paper by Mr. Geo. W. Lilly, Assistant City Engineer of Columbus, O., published in our issue of April 24. Believing that our readers would be interested to learn further particulars concerning this method, we have obtained the following concerning it from the officers of the railway company in whose work this method has been developed:

The girders supporting the High St. viaduct at the westerly end of the Union Station at Columbus, O., are in a position very much exposed to corrosion and to the effects of the fumes and blasts from engine stacks. In the endeavor to protect these girders from deterioration and possible destruction most of the best-known paints in this country used for the protection of steel structures have been applied to these girders in the most careful manner. Every paint tested on this viaduct failed absolutely to accomplish the purpose. Within six months as a maximum, even on the least exposed portions of the girders, most of the paint used as a protecting coat had disappeared.

The next method tried to protect these girders was to apply a coat of Portland cement mortar, consisting of the best Portland cement, sand and water. This covering was only a partial success, because, although applied to the clean surface of the metal with a trowel, in drying and setting the cement mortar drew away from the surface of the iron, leaving large voids between the covering and the iron, which were indicated clearly by a hollow sound when tapping the cement covering. Eventually the major portion of this cement covering became cracked on account of the vibration and the effect of the blast and fell off.

Next we endeavored to find some substance which would set more slowly and possessed more adhesive quality, avoiding if possible the drawing away and cracking of the protective covering. The following mixture and method of application was finally developed, and has proven fairly satisfactory up to the present time. It has now been in use on the girders about one year and shows little or no indication of failure.

1. The iron or steel surface should be made clean from rust and foreign matter by the use of sand blast, steel brush or file.

2. Apply a thick coat of Japan dryer on the clean iron. This must be done, however, just before applying the subsequent coating described below, so that the Japan dryer will not become dry before the application of said coating.

3. Apply with a trowel to the minimum thickness of 1-16-in. and maximum thickness of ¼-in. (in extreme cases ⅛-in.) a mixture of: 32 lbs. Portland cement, 12 lbs. dry finely-ground red lead, 4 to 6 lbs. boiled linseed oil, 2 to 3 lbs. Japan dryer.

While this mixture is still experimental, it has been tested a sufficient length of time to make worth while a more general test to effect possible improvements in the ingredients of the mixture.

Since the application of this mixture not more than ½ sq. ft. has shown any serious deterioration and this is at a point where it has been exposed to excessive heat and blast from engine stacks on account of the engines standing directly under it. Some portions of the mixture have been removed to examine the condition of the iron work, and at these points the iron was found in as clean a condition as it was before the application was made. The last examination of this coating was April 9, and it was found to be perfectly intact.

We are strongly inclined to the opinion that the best advice to any one proposing to erect structural steel where it will be exposed to the blast of a locomotive exhaust is: "Don't." The fact is well brought out in the above communication that any paint is powerless to protect metal so situated. Indeed, why should it be expected to withstand the combined sand-blast and acid-corroding effect of the locomotive exhaust? Exactly similar agencies are used by the engineer to remove from steel substances much harder and more resisting than a thin film of paint. A sand-blast action which can wear away white pine at the rate of 1¼ to 1½ ins. in four years (Eng. News, Oct. 26, 1899), is not likely to be particularly hindered by a thin film of ordinary paint.

Under these circumstances, the wise engineer who builds viaducts over railway tracks at the present day will at least use his influence for the adoption of some form of masonry or steel concrete construction; or else will devise some sort of concrete covering to protect his steel structure. Such a solution, however, offers little aid to the man who must take care of and preserve as best he can the structures which were built when the corrosion due to locomotive gases was not foreseen. For engineers who have such a problem on their hands, the experiments with the cement and red lead coating above described should possess great practical interest. While the method is still to be ranked as an experiment, it seems reasonable to believe that a coating which has three-fourths of its bulk composed of neat Portland cement and can be made to stick to the metal promises to be a fairly durable protection against the erosion of cinders from a locomotive stack.

An engineering editor would be a valuable acquisition to the staff of any daily newspaper. A few of the best journals of the country have engineers on their editorial staff, or at least keep in close touch with engineers of experience and good judgment, but such enterprise is rare, as many an engineer has found to his own amusement or sorrow.

A good illustration of the serious errors into which newspapers of general high reputation are often led by their lack of technical knowledge is afforded by the Philadelphia "Public Ledger," which years ago adopted and has since maintained a policy of hostility to the proposed introduction of water meters in Philadelphia. In defending this policy, it displays so deep an ignorance of the subject that a sample of its arguments seem to us worth reproduction. In its issue of May 24 "The Ledger" says that while there is doubtless "considerable waste" of water in the city, the proposed use of meters as a remedy "is impracticable and vicious." Besides the "enormous expense" of meters for every building supplied with water, it is declared that the meter system

would afford an opportunity for discrimination in the awarding of contracts to favored contractors, such as has been evidenced in connection with filters and filtration.

Has it occurred to the "Ledger" that the new pumps and boilers, the supplementary water mains and reservoirs and other accessories required to keep pace with the waste which it acknowledges also "afford an opportunity for discrimination in the awarding of contracts" and that the very filter contracts which it mentions as evidence of favoritism would involve far less money if the city had taken effective steps years ago, to throttle the water waste which has made Philadelphia notorious the country over?

As a further objection to the use of meters the "Ledger" states that water rents are now paid by landlords, and that if the practice were to continue "the tenant would have little compunction in wasting water," while, should the tenant be called on to pay water bills, "he would be constrained to consume as small an amount as possible," which "would be prejudicial to health."

But it is a very axiom of the art of water waste prevention that it is the waste and not the use of water which meters are designed to restrict. Following close on this is the well-established truth that a minimum yearly charge, based on a quantity large enough for the needs of a family, will entirely remove all reason for fearing that meters will prove prejudicial to health.

Again the "Ledger" urges—in its anxiety over sanitation—that in some parts of the city

the fault now is not that water is wasted, but that it is not used as freely as it ought to be.

But experience in a great number of cities has proved that with a minimum meter charge equal to the lowest annual charge for water in a house, a bathtub, at least, may be supplied with water in addition to the single kitchen faucet under the fixture rate for which the "Ledger" argues. All consumers, therefore, would have better water facilities by paying for metered water, and the penalty of carelessness would be placed where it belongs—on those who waste water. Moreover, purer water, as well as its more general use, is possible where waste is kept down.

Of a very different character from the Philadelphia instance, but still one showing the need of more engineering knowledge, or plain common sense, is the assumption by one of the Pittsburg dailies that the proposed new water purification works for that city need be of no larger daily capacity than the average daily consumption of water for the year.

How long could a great daily run if all its news-gathering, composing room, press and paper stock facilities were absolutely limited to the average amount of news that it gathered and published for the previous year?

INTERBOROUGH RAPID TRANSIT IN NEW YORK CITY.

In our issue of May 22 we published the announcement of the New York Rapid Transit Commission that surveys and plans had been ordered for a complete interborough system of underground passenger railways. It is safe to say that no more important announcement than this has been made in relation to rapid transit matters in New York city since the contract was closed for the Manhattan line, now under construction, in the early winter of 1900. No one believes, of course, that actual construction should be begun at once on a wholesale extension of the present Manhattan subway to the adjoining boroughs, but if such extensions are ever to be built, it is eminently desirable that they be planned for now, in order that the consecutive steps of construction, when they are taken, shall be from the beginning directed to a definite and well-determined object. It is the first principle of good business, as well as of good engineering, to plan in advance, and the most careful foresight is plainly warranted in the present instance. The magnitude of the proposed work is enormous from whatever point of view we choose to regard it. To carry it through wisely and economically demands the long and careful consideration of questions, not alone of engineering, but of legislation, finance and public service and policy. A glance at some of these questions may prove instructive.

The superior advantages of a single closely connected system of rapid transit railways for the city of Greater New York to any aggregation of

independent lines is manifest. Such a system means not only greater economy and convenience to travel between the several boroughs of the city, but it means a step toward the civic unity of these boroughs which is much needed. The expectation that it may bring about this unity of civic life is one of the most fascinating possibilities of the Commission's plan. When the Greater New York charter went into effect, on Jan. 1, 1898, it removed the political boundaries which had until that time existed between the component communities, which now make up the city of New York. It did not remove the natural barriers which existed between those communities, nor did it remove the barriers of local interests and activities which each community had developed within itself. To-day, therefore, New York city is a political unit, but otherwise each of its component boroughs leads a separate existence. Borough provincialism, for which there should be no place in a great city, has been the natural and inevitable result. To remedy this condition there can be no more potent force than to render the centers of city life as easy of access from one part of the city as from another no further distant. This end may be secured by a comprehensive and closely knit system of rapid transit railways, if it be planned in relation to the city as a whole and if no artificial barriers be raised in the form of discriminating fares and facilities.

Another general feature of the Commission's plans which deserves particular notice is that they embrace all the existing and proposed routes and their future improvement. For example, they propose and have under way the consideration of a comprehensive terminal for the several East River bridges. They also include the devising of a franchise and contract for the operation of the Pennsylvania R. R. tunnel from New Jersey to Long Island, and, finally, they propose to work out, in connection with the New York Central & Hudson River R. R., the means by which a change of motive power in the Park Ave. tunnel can be secured. All this work, it must be understood, is in addition to and in conjunction with the construction of new lines of subway, which is the particular function of the Commission.

The importance of the Commission's decision to utilize its full powers in controlling rapid transit matters in New York city is evident. It makes certain, first of all, that future improvements of existing routes in the line of underground extensions will be so designed as to supplement and fill out the rapid transit railway system, as well as to subserve their own particular purpose. It ensures, furthermore, as the Commission points out, that relatively unimportant franchises will not be granted in such a way, or special routes be so devised, as to prevent or obstruct the development of a comprehensive subway system. Finally, it makes it possible for certain needed improvements, such, for example, as are necessary for the change of motive power in the Park Ave. tunnel, to be prosecuted without applying for permission to a number of separate and often antagonistic municipal bodies.

As many of our readers will remember, the last New York Legislature, just before its adjournment, passed a bill requiring all trains passing through the Park Ave. tunnel of the New York Central & Hudson River R. R. to be operated by electricity by May 1, 1905. The magnitude and importance of this innovation and the circumstances which prompted it have been fully discussed in preceding issues of this journal. The point to be noted, particularly at this time, is that in the formal announcement of its plans, on May 15, the Rapid Transit Commission cordially invites the New York Central & Hudson River R. R. to apply for the necessary permission to make the tunnel alterations required to use electric motive power. This action removes the only remaining barrier to the preparation of plans for the electric operation of the Park Ave. tunnel and the commencement of the most extensive piece of work in the substitution of electric motive power for steam locomotives ever undertaken.

Important as this phase of the Commission's plans is, it is exceeded in importance, in popular estimation at least, by the proposed extensions of the Manhattan subway. As our readers know, plans have been practically completed and bids will soon be invited for constructing a double-track extension from the present postoffice terminal down Broadway and thence across the East River to a connection with the Long Island R. R. terminal in Brooklyn. So far this is the only extension of the subway outside of Manhattan and Bronx boroughs that has been formally proposed. On May 1, however, the chief engineer of the Commission was instructed to submit plans for an East Side extension in Manhattan, to start from the present line at Park Ave. and 42d St. The survey of this extension does not, of course, necessarily mean that it will be the extension next constructed, but there is every probability that it will precede the building of any other line than that now planned for outside of Manhattan. No other extension is at present more urgently called for, assuming, of course, that the proposed Broadway-Brooklyn extension has been definitely settled upon. In fact, its inclusion in the original Manhattan line was only prevented by the practical prohibition placed upon the Rapid Transit Commission not to exceed an expenditure of $35,000,000 in building that line.

The work which will succeed the extensions enumerated and the order in which it is likely to be carried out are largely matters of speculation. From present indications, however, the next demand will probably be for an extension of the Brooklyn system, with, perhaps, the construction of one or more East River tunnels to join it with the Manhattan lines. The present lines, with some slight extension, perhaps, should meet the needs of the Bronx for a number of years to come. Richmond Borough, on the other hand, is at present entirely unprovided for, and it will be many years, probably, before its needs will justly demand the long submarine tunnel extension necessary to connect it with the systems of the larger boroughs of the city.

It is evident from what has been said that the problem of deciding between the rival claims of the different boroughs for precedence which will confront the Commission is one of considerable intricacy. The crucial problem, however, is certain to be one of finance. Fortunately, this problem is not so uncertain as it was three years ago. Then it was necessary in order to secure the construction of an underground railway lengthwise of Manhattan Island for the city to loan its credit to the undertaking, so skeptical of the success of tunnel transit were capitalists. We are inclined to believe that this was perhaps the best possible thing that could have happened, but however this may be, the point we desire to note here is that capital now offers itself for the construction of any reasonable number of extensions of the subway system which it once shunned.

The letter of Mr. August Belmont, published in our issue of May 22, formally offers the aid of private capital to the Rapid Transit Commission in the following terms:

> The operating company, which will shortly be organized, representing the same interests as the Subway Construction Co., will be prepared to construct extensions and connections with its own capital and credit, provided the means and methods can be arrived at for doing so. I suggest as a plan approved by our executive committee that such extensions and connections can be built on bonds of such operating company, which necessarily will have to bear a higher rate of interest than the city bonds, convertible into city bonds at the option of your commission, the construction being in all details conducted precisely in the same manner as the present work is being done, and becoming a part of the system as a unit.

Put into different language, Mr. Belmont offers to construct extensions and connections with his own capital and credit, and at the same time preserves the city's right of ownership and the charter prohibition of perpetual franchises by providing that the bonds of his company be made exchangeable for bonds of the city at its wish and convenience. The proposition is a far-sighted one, and should the debt limit of the city make it impossible to issue bonds for rapid transit extensions as fast as these are demanded it is a proposition which should receive careful consideration.

Will it be necessary for the city to resort to such outside aid as Mr. Belmont offers? We are not at all certain that it will. The main line of subway in Manhattan is already provided for, and so is the proposed double-track tunnel to Brooklyn. The only other line that calls at all for immediate provision is the so-called East Side extension of the Manhattan subway, and the Rapid Transit Commission has already set on foot inquiries whether the city may not be able to provide the money for this work. Let us note here that there would be no doubt of its ability to do so were the construction of the foolish $25,000,000 Third East River Bridge abandoned, as we urged should be done in our issue of May 22. Indeed, in view of the willingness of private capital to build subways and tunnels at its own risk, trusting to pay for them and get its own profit from the earnings in the period before they revert absolutely to the city, coupled with the doubtful need of the Third East River Bridge and the practical certainty that it will not pay interest and operating expenses for years, the folly of wasting $25,000,000 in the construction of this bridge is more evident than ever before.

To summarize briefly, it is by no means certain that the city has not already the means for building all the subway extensions for which there is present need. In fact, it is quite certain that it has the means for this work providing it withdraws the unwise step it took in 1899 to build the Third East River Bridge. In view of these possibilities it would be to our mind unwise to be in haste to accept the aid of private capital for developing future underground railway lines. It must not be forgotten that before the Rapid Transit Commission can avail itself of the aid of private capital special legislation must be had. We presume that such legislation can be obtained, and it means, if secured, a material addition to the powers of the Commission.

The Rapid Transit Commission now has power to build subway and tunnel lines for rapid transit purposes in the city of New York wherever and whenever it chooses subject only to the debt limit of the city and to the approval of the Supreme Court. It has the power to grant permission to existing transportation lines to construct underground terminals and extensions subject to its approval. The new legislation would place in its hands power to enlist private capital in the construction of subway and tunnel lines whenever the funds of the city were inadequate to its assumed needs. These are enormous powers to be placed in the hands of a single body of men. No one can justly question the conservatism and public spirit of the present Commission, and we may confidently assume that these powers are safe in its hands. It can be readily foreseen, however, that events might bring about a condition of affairs where the public would come to rue its action in abrogating its powers to the extent necessary to enable the Rapid Transit Commission to use private capital at its will to effect public improvements. There are already many persons who think that the Commission should make a decided effort to get a better contract for the operation of its future lines of subway than that now in force between the city and the company building the Manhattan line. We shall take occasion to discuss this question in a future issue, but here we mention it merely to show that public opinion is likely to develop strong opposition to placing further control and management of rapid transit matters in New York city in the hands of private capitalists.

LETTERS TO THE EDITOR.

Steel Wheelways for Wagon Roads.

Sir: I have seen in Engineering News of May 8 an article on the subject of steel wheelways for wagon roads by Prof. Ira O. Baker. The U. S. Department of Agriculture has been interested in this question for a number of years, the present director, Hon. Martin Dodge, having been the first, I believe, to bring the matter to the attention of the general public. A few investigations and experiments have been made from time to time, as you will notice from the enclosed article by Mr. Dodge, taken from the "Yearbook" of this department for 1898. From this article you will see that sections of steel-track wagon roads were built by the Office of Public Road Enquiries at Omaha, Neb., St. Anthony Park, Minn., and Ames, Ia.

So far as I know, these are the only tests that have been made under the auspices of this office, but by referring to Professor Baker's article, I find that he states as follows: "The only practical test of a steel wheelway ever made in this country was upon a section built in Chicago in 1901,

from designs prepared in the Office of Public Road Enquiry of the U. S. Department of Agriculture." Then Professor Baker goes on to say that the experiment was unsuccessful and presents the reasons therefor, leaving the general public to infer that the fault was with the designs prepared in this office. Why Professor Baker should have criticised an unofficial tests of this system, instead of some of the more successful experiments outlined and discussed in the "Yearbook" of this department in the Engineering News and in the other leading magazines and papers I cannot understand. Truly yours,

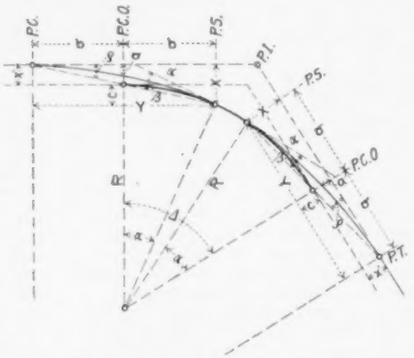
M. O. Eldridge, Acting Director,
Office of Public Road Enquiries.

U. S. Department of Agriculture,
Washington, D. C., May 20, 1902.

(The article in the Yearbook mentions some short sections of track, but gives no information whatever as to the details of construction, the traffic, or any tests as to tractive power required. In fact, nothing is said as to any tests, or as to the behavior of the pieces of track in actual service. Whether they lasted after being laid as "object lessons" we do not know. Prof. Baker's article described actual tests of the longest piece of steel wheelway yet built, but so far as we know the government officials made no such tests on their experimental sections.—Ed.)

Computing Transition Curves of Various Lengths.

Sir: The discussion with regard to lengths of easement curves to be employed on curves of various degrees, and for different speeds of traffic, given by Mr. W. D. Taylor, M. Am. Soc. C. E., in your issue of April 17, 1902, has induced the writer to present what he has found to be an easy method of locating easement curves of lengths and rates of increase, not ordinarily found in tables prepared for such work. The transition curve used is the cubic parabola.



Referring to the figure it has been proven that for the cubic parabola, $\tan \alpha = \frac{12\,a}{b}$; $b = \frac{1}{2} Y$ ∴ according to the equation for the cubic parabola ($x^3 = k\,y$), $X = 8\,a$.

By assuming any desired value for Y, we may compute a corresponding value for X, as follows:

$$\sin \alpha = \frac{b}{R} \quad \therefore \quad \alpha = \sin^{-1} \frac{b}{R} \qquad (1)$$

$$\tan \alpha = \frac{12\,a}{b} \quad \therefore \quad a = \frac{b \tan \alpha}{12} \qquad (3)$$

$$\text{But } X = 8\,a \quad \therefore \quad X = \frac{2\,b \,.\, \tan \alpha}{3} \qquad (4)$$

$$\tan \rho = \frac{X}{Y} \quad \therefore \quad \rho = \tan^{-1} \frac{X}{Y} \qquad (6)$$

$$\beta = \alpha - \rho. \qquad (5)$$

$C = R\,\text{vers}\,\alpha$, or $c = b \tan \frac{1}{2} \alpha$.

$X - C = X^1 =$ offset for circular curve.

The P. S. and middle points of the transition curve may be located from values obtained by the above formulas. Other points on the curve may be located by computing offsets from the tangent by substituting the formula $x^3 = k\,y$, or deflection angles and distances from the P. C. may be computed if desired.

The circular portion of the curve may be run in either from the P. C. O., or from the P. S., by backsighting on the P. C. and turning off the angle β.

Many of the above calculations may be performed with sufficient accuracy on the slide rule, which simplifies the calculations considerably.

Yours truly, E. W. Hyde, Jr.
Construction Department, Illinois Central R. R.
Paducah, Ky., April 26, 1902.

THE BOSTON MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The most largely attended convention ever held by this society was that held at Boston on Tuesday to Friday, inclusive, of last week. The total number of members and guests registered up to the close of the convention was 862. This large registration is partially explained, perhaps, by the very large number of ladies present, drawn thither by the well-known attractions of Boston and the fine program of entertainments and excursions prepared by the local reception committee.

The society may be said to have been the guests of the Massachusetts Institute of Technology, as the headquarters were located and all save one of the professional sessions were held in the "Engineering Building B" of that institution.

The opening session on Tuesday evening, held at Huntington Hall of the Institute, was, as usual, a social affair. The visitors were welcomed in addresses by Dr. Henry S. Pritchett, President of the Institute of Technology, and by Mr. Geo. A. Kimball, President of the Boston Society of Civil Engineers.

BUSINESS SESSION.

On Wednesday morning the usual business session of the society was held, but it soon developed into a very unusual business session, for the work of "housecleaning" which was begun last December at the New York meeting, was again taken up and pushed forward in a most vigorous manner.

The session opened with the usual routine business, reports of tellers on the election of new members, etc. Notice was then given of two proposed amendments to the Rules of the Society, each of which has for its purpose the establishment of the letter ballot upon any changes in the Rules. The amendments will be acted on at the meeting next December.

Some weeks prior to the meeting, a special report of the Council to the Membership on the financial status of the society had been distributed to the membership. The report, with appendices, forms a 23-page pamphlet. Briefly summed up, it shows that the society has a floating debt amounting at the close of its last fiscal year to about $15,000. Its income last year was $38,782, and its current expenses used this up within about $200. Various small economies have been inaugurated which are expected to reduce expenses this year about $2,500. The Council, however, evidently does not relish the policy of economy and it again brought forward a recommendation that the membership dues be raised, this time to $20 per annum.

The tone of this Council report is well illustrated by the following extract:

> The Council cannot believe that in a permanent policy of the society's holding its breath and marking time with respect to progress it can expect to carry with it the strong support of the membership at large. A society which does not progress is really retrograding, and instead of holding its own it should actively and aggressively advance.

This special report of the Council was then taken up, and after some general remarks it was voted to appoint a committee to revise the Rules of the society in accordance with a motion made by Past-President Henry R. Towne, which was substantially as follows:

> That the Chair appoint a nominating committee of three which shall before the close of this convention nominate three members to undertake a revision of the rules of the society, such revision to be distributed to the members some time in advance of the December meeting.

At the last session of the convention on Friday, the Chairman, Mr. Jas. M. Dodge, appointed as a nominating committee Messrs. Ambrose Swasey, of Cleveland; J. T. Hawkins, of Boston, and Wm. O. Webber, of Brookline. After retiring for a few minutes the committee returned and reported the names of Messrs. C. W. Hunt and Henry R. Towne, of New York, Past-Presidents of the society, and Mr. Jesse M. Smith, of New York. These names were allowed to stand as the committee to revise the rules without the formality of a vote.

Returning to the proceedings of the business meeting on Wednesday: Mr. Fred. J. Miller, of the Finance Committee then presented a careful statement respecting the present condition of the society, which so evidently expressed the sentiment of the great majority of the members present and dealt with matters of such importance to the society that we print it nearly in full, as follows:

> I think it will be agreed that this report, in which the Council (I am tempted to say for the first time) takes the members of this society into its confidence and places before them a complete statement of the society's affairs, forms an excellent basis for intelligent action by the membership; and this confidence, I am persuaded, is not misplaced. The society is composed of grown men, most of whom are more or less trained men of affairs, and those qualifications which entitle them to membership entitle them to know, to discuss and finally to decide upon matters of business connected with the society.
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> There are a few points in this report to which I desire to call attention and concerning which it seems proper to ask a few questions: At page 3 the statement is made that during the twenty-two years of the society's existence it has accumulated a surplus of over $73,863. It is evident from this that the average receipts of the society from all sources have exceeded its average expenditures (by about $3,350.00 per annum). If during the past few years, this annual surplus has been turned into a deficit, then it is the part of wisdom to carefully consider the reasons therefor and then to consider whether the increased expenditure per member is wise or necessary, and I have no doubt that a majority of the members would favor such increase of dues as had been shown to be clearly necessary after proof that the society's affairs have been for a time well managed—managed in a business-like manner; but not otherwise.
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> On page 5 the character of the published volumes and the quality of the papers printed by the society are referred to, and it is stated that "so far from curtailing these, the society should expand in the direction of more papers of wider interest, of superior quality and usefulness, even if it must expend something more to attain these results." I think every member will agree that an improvement in the practical usefulness of the papers presented before this society is desirable; but can such improvement in the papers be secured by the mere expenditure of money? It seems to me doubtful; but possibly different, though not necessarily more expensive methods might readily bring about such an improvement.
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> Though the conclusion of the Council regarding the efficiency of the present management of the society will probably be accepted by many, I think there are many other members who will not be disposed to accept it as the final conclusion. There is a quite prevalent and perhaps growing conviction that this society will never be able to do all that it should do, nor to develop the degree of usefulness it should develop, and might develop, until it has a secretary who is not only efficient and business-like, but who can devote his entire time to the affairs of the society, and will have no other interests which he may consider paramount. I do not pretend to say that this view is correct or not, and indeed I am not yet satisfied in my own mind regarding it, but this much I feel sure of, i. e., that the question should receive careful attention and the views of the members should be obtained and considered in relation to it. I think it will be found that, generally, they will be less interested in knowing whether or not we pay more or less than another society, than in knowing whether or not we are doing the best that we can do.
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> On page 6 the cost of operating the society's house is given as $3,783 per annum, and figures are given to show that the minimum space that would be required in which to do the business of the society would cost nearly as much if rented and perhaps more. I doubt if there is as much profit in the mere renting of property in New York City as these figures indirectly show. Without going into figures at all it seems, on the face of it, that the maintenance of this house is an expensive luxury, and the figures given are not I think sufficient to dispel this impression. I believe the amount stated as the net cost of operating does not include interest. Certainly the interest actually paid out on the mortgage indebtedness should be included, and in fact interest at say 4% on the entire valuation of the property should be included, and this 4% of $85,000 = $3,400, should be added, making the total net cost nearly double the amount given. Admitting the force of what is said about the advantages of the society owning its own house, the question is still open as to whether we are not paying rather dearly for these advantages—especially when it is considered that the house has become totally inadequate for its chief purpose.
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> Near the top of page 7 it is explained why the cost of operating the society per member does not fall so rapidly as it would, or might, under other circumstances. Of course we all understand that where fixed charges enter into an expense account, expense per capita cannot be reduced in proportion to increase of membership; but as a matter of fact the report indicates that the expense per member has not fallen at all within the past few years, but has increased, and the members of the society will, I believe, generally not be entirely satisfied until that increase is satisfactorily accounted for and probably not until the increase is arrested.
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> Referring to the "recommendations for the future" (quoted above—Ed.), I believe that no member of the society believes that it should, in the language of the report, "hold its breath, mark time and fail to progress." It is simply a question of how we should progress, or in what way we should progress. Rightly or wrongly, very many members now believe that we were, last fall, in danger of attempting to progress along a path in which no real or satisfactory progress would have been possible. They believe that the Council was led to inadvertently approve measures which not a single member of that Council would have considered for one moment in connection with his own business, where he alone would have been responsible for the results. It does not follow that these members—sincere well-wishers of the society, I am sure—are in favor of the society's holding its breath and marking time" simply because they do not think it is wise to follow a certain specified course. My belief is that the quality of the "Transactions" can be improved without materially increasing the cost of them, and it is open to debate, doubtless, as to whether we do not publish a good deal of matter that is of little value. Those who are at all acquainted with the printing business know that tables in printed matter are an expensive luxury, and it is doubtful if a very large proportion of the members of this society derive much benefit from many of the expensive tables giving long detailed accounts of tests of engines and boilers which so abound in our transactions. Perhaps the gist of these things might in many cases be given without publishing page after page of long tables which are of doubtful value. And much the same may be said of fully worked out mathematical demonstrations.
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> The best and perhaps the most hopeful feature of this report is to be found on page 16, where the finance committee recommends that a committee be appointed to make a general revision of the Rules of the society. This, it seems to me, is not the time to attempt a general discussion of the things which the society should do or should not do; such discussion should be carried on later, either at the fall meeting in New York or elsewhere, in connection with the consideration of the work of the committee which Mr. Towne's resolution provides for. It seems to me that this is a good opportunity to set in motion the machinery of forces which may eventually lead to a betterment of the general condition of the society, whose best interests I feel sure we all have at heart.

Mr. Miller's address was heartily applauded, and it started a brisk and most interesting discussion upon the general condition and needs of the society, in which a number of members expressed most vigorous disapproval of the general conclusions reached by the Council in its published report. Perhaps the thing that received strongest condemnation was the idea expressed by the Council that no further reduction in the running expenses of the society was possible.

Mr. Harrington Emerson, of Philadelphia, in a vigorous speech declared that he had lived for four months at the society's house and had seen abundant evidence of waste and mismanagement. He believed, from what he had there seen, that it was entirely possible to reduce the society's expenses $10,000 per annum, with no reduction in the efficiency of its work.

Of course the element in the society which favors an increase of dues and condemns "picayune economies" was also heard from. In fact most of the debate was nominally upon a motion that the society should send copies of its papers to every member, instead of as at present sending these copies only to such members as signify on a return postal card their desire to have them. This motion was finally tabled by an overwhelming vote.

Following this debate two important motions were passed without debate and without opposition.

The first of these made by Mr. Wm. Kent (Assoc. Ed. Eng. News.), increases the publication committee to eight members and the secretary. Sub-committees of two are to be formed from this to cover the various branches of professional work, and each paper offered is to be referred to that sub-committee in whose department it naturally falls, the approval of which in writing is necessary to the paper's acceptance.

The second motion, by Mr. Gus. Henning, relates to recent agitation before Congress by a committee of the society against the pending legislation in Congress on the metric system. He declared that the committee had no right to take such action without formal action of the society, and the resolution, which was adopted, specifically forbids any committee of the society undertaking to represent the society in any public way without specific authorization by the society itself. This concluded the business session and the technical work was begun.

FINAL REPORT OF THE COMMITTEE APPOINTED TO STANDARDIZE A SYSTEM OF TESTING STEAM ENGINES.

This report was the first on the programme of technical papers. The committee consisted of Messrs. Geo. H. Barrus, Francis H. Boyer, the late Bryan Donkin, of England, D. S. Jacobus and Geo. Richmond. Prof. Jacobus briefly presented the report and discussions were read by Messrs. E. T. Sederholm and Wm. S. Monroe, of Chicago, and Chas. L. Heisler, of Erie, Pa. There was also oral discussion by Prof. Spangler, of the University of Pennsylvania, Prof. Lanza, Prof. S. A. Reeve and Messrs. R. A. Smart and F. H. Ball. Most of the criticism was directed towards minor points in the report, and Prof. Jacobus stated that all the criticisms would receive due attention in revising the report for final publication.

SUPPLEMENTARY REPORT OF COMMITTEE ON STANDARD PIPE UNIONS.

The "Final Report" of this committee was made at the New York meeting last December, but since that time certain criticisms of the standard design have been made, and these were brought before the society by a member of the committee. They were discussed by Messrs. W. B. Forbes, E. M. Herr, C. W. Nason and others, but no action was taken. This concluded the morning session.

After adjournment the visitors were ushered into an adjacent room, where a substantial luncheon was ready. After this had been sufficiently discussed, groups of ten or a dozen were organized under charge of a guide and an inspection was made of the principal buildings and laboratories of the Institute of Technology. Few, if any, engineering schools anywhere can boast a more complete equipment in the way of apparatus; the only criticism that could be made is that everywhere lack of space is evident. The present university buildings are all located within a stone's throw of Copley Square, in Boston's Back Bay district, where real estate is worth enormous prices. Before undertaking further extensions to the present buildings, the project is being seriously considered of removing the entire plant of the institution to some site in the outskirts of the city, where a large tract of land could be secured at a low figure and spacious buildings specially designed for the use they are to be put cculd be erected.

SPECIFICATIONS FOR STEEL FORGINGS, STEEL CASTINGS AND STEEL BOILER PLATES.

This paper, by Mr. Wm. R. Webster, of Philadelphia, was the first one taken up on Wednesday evening. These specifications, prepared by the American Section of the International Association for Testing Materials, were printed in Engineering News of July 21, 1901. A long and severe criticism of these specifications was presented by Mr. Gus. C. Henning, and brief discussion was also given by Mr. S. M. Vauclain and Prof. Lanza. The former thought the specifications were too cumbersome for every day commercial work.

TESTS OF STEAM PIPE COVERINGS.

Mr. Geo. H. Barrus in this paper described some tests of steam pipe coverings which he carried on at New York last fall and which were described in our issue of Nov. 21, 1901. From the results of these tests it appears that with coal at $4 per gross ton the cost of the heat lost per annum from a square foot of pipe kept hot 24 hours a day and 365 days in the year is as follows: From bare pipe, $1.27 to $1.61. From pipe protected by various coverings, 15 cts. to 33 cts. The loss per square foot is greater from small size pipes than from large size and increases with increase in the steam pressure.

Prof. Jacobus reported a very similar series of tests with results almost identical with those obtained by Mr. Barrus. Prof. Crosby called attention to the fact that these tests were all on sectional coverings. As 20% to 35% of the exposed surface in a piping plant is made up of valves and specials which require plastic non-conductors, tests of the qualities of such materials are also important.

ELEVATOR SAFETIES.

In this paper Mr. Chas. R. Pratt described with the aid of stereopticon views a new safety stop for elevators which he has developed. We shall print this paper in our next issue.

THE ATLANTIC AVENUE STATION OF THE BOSTON EDISON CO.

This paper, by Mr. R. E. Curtis and I. E. Moultrop, Engineers of the Edison Co., and the following paper, by Mr. Curtis, describing a swivel expansion joint on a steam pipe, are both reprinted in this issue. They were of particular interest, as the station itself was visited in the excursion on Thursday, and members inspected for themselves the construction described in the paper.

TESTING GAS ENGINES.

Next came two papers by Mr. R. H. Fernald, a graduate student in Columbia University. The first of these described a method of taking the temperature of the exhaust gases from gas engines. It consists, briefly, in discharging the gases into a receiver lined with non-conducting material and suspending thermometers in the receiver. The surprising part of the paper is Mr. Fernald's claim that the exhaust temperatures of gas engines are enormously high, say, from 1,400° to 1,800° F. before their expansion consequent upon release. This result he obtained by computation, and claimed that with exhaust gases at atmospheric pressure and 70° temperature, their temperature before release from a gage pressure of 35 lbs. would be 1,341° F. No one questioned this statement, however, and Mr. Fernald then read a paper describing "Working Details of a Gas Engine Test." This was a 63-page pamphlet, the title of which is a sufficient abstract. It was not discussed.

LIQUID FUEL COMBUSTION.

This paper, also presented by Mr. Fernald, described experiments of Mr. Chas. E. Lucke, of New York, in burning liquid fuel under peculiar conditions. The fuel oil used is difficult stuff to burn, but success was finally attained by directing a forced flow of oil and air into the base of a pile of broken magnesia brick. The paper describes a variety of experiments made in the course of developing a successful oil burner, and will interest anybody who has a similar problem to tackle.

Nobody wanted to discuss this paper, as it was past 11 o'clock by the time the session was concluded.

A ROLLER EXTENSOMETER.

This new instrument, for use in the testing of materials, was described by its inventor, Mr. Gus C. Henning, at the opening of Thursday's session, and he exhibited one of the instruments and explained its operation.

A MECHANICAL STOKER FOR LOCOMOTIVES.

This paper, by Mr. F. H. Colvin, described the Kincaid locomotive stoker, which has been used on the Chesapeake & Ohio R. R. This paper we reprint on another page of this issue.

Mr. R. H. Soule said that mechanical stoking for locomotives was a necessity if further increase was to be made in the size and power of locomotives. Mr. Geo. L. Fowler said that he had seen the stoker in service, and it worked surprisingly well. The chief defect is the tendency to leave the coal thin in the corners, so that holes are blown in the bed of fuel by the exhaust.

AN IMPROVED INDICATOR COCK.

Mr. A. K. Mansfield, of the Buckeye Engine Co., described in this paper a 4-way indicator cock which has its fourth outlet piped to the steam space of the engine throttle or to the exhaust pipe, or, when used on the low-pressure cylinder of a compound engine, to the receiver space. With this cock cards may be taken showing the drop in pressure due to the friction of the steam flowing through the pipes. Mr. Mansfield also pointed out the ambiguity in the term "initial pressure" in engine specifications, and proposed that it be defined as "the realized pressure in the cylinder just before cut-off begins." In the discussion some opposition developed to this proposed definition.

ELECTRICITY IN COTTON MILLS.

This paper, by W. B. S. Whalley, of Boston, purported to give figures of the engine and dynamo losses in the Olympia Cotton Mills, and tables and diagrams were presented which showed a total loss in engine and generator of less than 3% of the total power output. These figures were sharply criticised by Mr. F. W. Dean and Prof. C. H. Benjamin. They are undoubtedly so misleading and erroneous that they ought not to go on record in the "Transactions."

SOME DETAILS OF DIRECT-CONNECTED GENERATOR SETS.

Mr. Wm. H. Bryan, of St. Louis, in this paper described:

First.—The procedure usually followed between the builder of the generator and the builder of the engine in reaching an understanding regarding the detailed design of shaft and bearings.

Second.—The method of construction and final erection preferred.

Third.—The advantages and disadvantages of a shaft coupled by flanges, as compared with a continuous shaft.

This paper gave rise to considerable discussion, largely directed to Mr. Bryan's suggestion that an engine, like a generator, ought to be guaranteed to carry safely 50% overload. Against this the engine builders protested, while the consulting engineers rallied to its support. Time was too short, however, to permit an extended discussion, as the session had to adjourn promptly for the afternoon's excursion. The next paper, by Mr. J. V. Le Conte, of Berkley, Cal., on "Graphical Determination of Piston Acceleration," was hastily read, and as no discussion was offered, the meeting adjourned.

EXCURSION TO FORE RIVER SHIP & ENGINE WORKS.

Thursday afternoon was given up to an excursion to Quincy by steamer and trolley cars, and on their way to the steamboat the visitors passed through and inspected the fine new power station on Atlantic Ave. of the Boston Edison Co., referred to above, and described in the paper on page 465 of this issue.

A number of the members also improved an opportunity to see a self-propelled fire engine at one of the Boston fire stations near by put through its paces. It operated in a most satisfactory manner, showing its ability to make a quick start, attain high speed, and manoeuver, in contracted quarters in much better shape than a horse-propelled machine. The entertainment was varied by the pulling out of the suction hose from the coupling and a liberal and unexpected shower bath in consequence, which scattered the onlookers in a hurry.

All the visitors (including the ladies, who had been on a trolley excursion during the morning) finally assembled on the steamer which then proceeded down the harbor, the party on board taking luncheon meanwhile.

At Crow Point landing in Hingham, a line of open trolley cars was in waiting, and by these the party was conveyed to the works of the Fore River Ship & Engine Building Co., in Quincy. Space permits not even a summary of the interesting things which were seen here. We can only mention two things that attracted great attention: The admirable system of conveying materials in operation in the new ship house, where the hulls of the battleships "New Jersey," and "Rhode Island" are fast assuming shape and the huge 7-masted schooner, towering high in the air, and now nearly ready for launching. Her ponderous steel masts, each a hollow cylinder of steel plate, strengthened with channels riveted on the inside and weighing over 17 tons, were nearing completion and are to be set in place and rigged before the vessel is sent off the ways. The launch will probably take place about the middle of July.

The return homeward was made by the same route. The excursion was a thoroughly enjoyable one, the only drawback of any sort being the chilly weather, the day being the coldest May 29 ever recorded by the Boston Weather Bureau. However, the warmth of the hospitality of the Boston members fully compensated for the idiosyncrasies of the New England weather.

RECEPTION AT THE MUSEUM OF FINE ARTS.

The finest social event of the entire meeting was the reception tendered to the visitors at the Museum of Fine Arts on Thursday evening. It is the rarest of events for this institution to open its doors for such an entertainment, and it speaks volumes for the high standing of the Boston members of the profession that the Local Reception Committee were able to obtain such a privilege for their guests. A large number of prominent residents of Boston, outside the Society, were among the invited guests, and besides the art treasures of the Museum a fine orchestra and a handsomely served collation added to the pleasure of the evening.

SESSION AT HARVARD UNIVERSITY.

The final session of the convention was held on Friday morning at Pierce Hall, in the new Engineering Building at Harvard University in Cambridge. The auditorium was filled to its capacity and many of the members spent the time in visiting the various buildings and places of historic interest, or attending the Memorial Day exercises in Sanders Theatre.

A TECHNICAL INDEX AND FILE.

Mr. R. H. Soule, the author of this paper, which was first on Friday's program, described his system of filing clippings from trade catalogues, technical journals, etc., and the card index by which reference to the matter is made easy.

The paper was discussed at length by Messrs. H. P. Quick, Supplee, Fowler, Lane, Oberlin Smith, and others, and considerable difference of opinion developed as to the best methods of filing clippings. The need of manufacturers adhering to standard sizes in printing their catalogues was brought forward, but Mr. Soule said he feared it was a hopeless task to induce manufacturers to conform to these standards.

A STEEL AND CONCRETE COAL STORAGE PLANT.

This paper by Mr. F. M. Bowman describes a unique coal storage plant, in which the coal rests directly on the ground, instead of being stored in elevated pockets as is

customary. We print the paper on p. 463 of this issue. There was no discussion.

REPAIRING A BROKEN CYLINDER.

Mr. H. M. Lane, of Scranton, in this paper told how a casting was made to repair a broken steam engine cylinder, and how a plaster of paris cast was made and used for a pattern instead of laboriously carving out a wooden pattern. It was an ingenious makeshift, which answered surprisingly well. No one offered to criticise the scheme and the next paper was taken up.

THE FLYING SHEAR—COLD WORKING OF SHEET METAL IN DIES.

These two excellent contributions were presented and discussed together. The first of these, by Mr. V. E. Edwards, will be found on p. 453 of this issue; the second, by Mr. J. D. Riggs of Pittsburg, we hope to find space for next week. The discussion was directed to the latter paper, and speedily resolved itself into a lively competition as to who could tell the biggest story regarding the rate of production of sheet metal presses. It was shown that by the use of gang dies some of these presses turn out small articles, such as cartridge shells, crown tops for bottles, etc., at the rate of over a million a day. The best illustration of the cheapness with which sheet metals are worked in the press is that many small articles made of sheet brass can be bought in Connecticut for a lower price per pound than the cost of the sheet brass from which they are made. The explanation of this apparent anomaly is that these small articles are made from the waste left by machines producing larger work, which waste is only marketable as scrap unless it can be worked up for smaller pieces.

STANDARDS FOR SMALL MACHINE SCREWS.

This was one of the most important papers presented to the convention. It outlines a proposed standard for machine screws less than ¼-in. in diameter, where no standard now exists. The need for such a standard was made evident in the discussion, and it was voted that a committee of five be appointed to formulate such a standard and present it to the Society.

This concluded the list of technical papers. The Vice-President, Mr. Jas. M. Dodge, who occupied the chair at all the meetings, in the absence of Mr. Edwin M. Reynolds, the Society's President, announced that he would leave to Mr. Reynolds the appointment of a nominating committee to select candidates to be voted for next fall. Appropriate resolutions of thanks were adopted expressing the appreciation of the visitors for the entertainment and hospitality which they had enjoyed and the final adjournment was then taken.

Afterward the whole party assembled in the beautiful Memorial Hall of the University where tables had been spread and a substantial luncheon was served, after which President Eliot, of the University, bade the visitors welcome in a well-chosen speech.

Thus concluded the most largely attended and in many respects the most notable convention ever held by the American Society of Mechanical Engineers.

THE 50,000-VOLT TRANSMISSION PLANT OF THE MISSOURI RIVER POWER CO. IN MONTANA.

By W. G. McConnon.*

Although several plants have been proposed for the use of voltages higher than 40,000, the distinction of being the first to place in actual commercial service a large plant employing 50,000 volts transmission belongs to the Missouri River Power Co. This installation was completed and the apparatus placed in operation about the first of March, of the present year, and much credit is due to the General Manager and Engineer of the company, Mr. M. H. Gerry, Jr., M. Am. Inst. Elec. E., who planned and executed the general undertakings, as well as to the Westinghouse Electric & Manufacturing Co., who furnished the electrical equipment.

*Consulting Engineer, Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

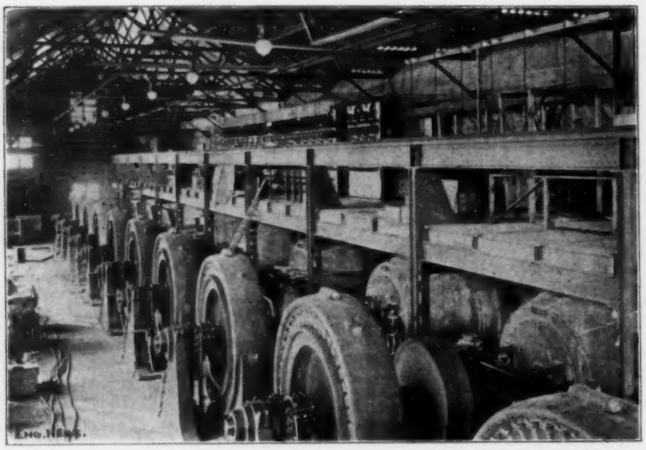


FIG. 1. INTERIOR OF POWER HOUSE OF MISSOURI RIVER POWER CO., AT CANYON FERRY, MONT.

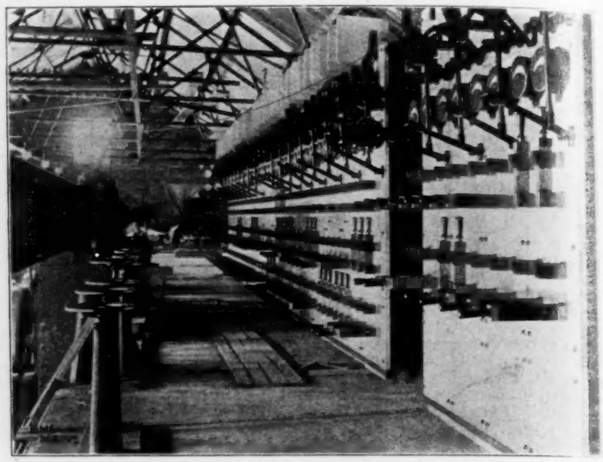


FIG. 2. SWITCHBOARDS AT CANYON FERRY POWER HOUSE.

It is to be noted that since the starting of the plant there has been no mishap of any kind to the line or apparatus. This, the writer believes, is somewhat exceptional in undertakings of this magnitude and character, since it is generally expected that at the start minor difficulties are liable to be met with, which, though possibly not serious, will nevertheless affect the continuous service of the plant.

The present power house of the Missouri Power Co. is located on the Missouri River about 20 miles east of Helena, Mont. To those who are familiar with the early history of the Northwest it will be recalled that in the famous Lewis and Clarke expedition of 1803-4 up the Missouri River and across the continent to the Pocific, one of the resting places and points of interest spoken of is Black Rock Canyon, met with soon after entering the Rockies. Black Rock Canyon is not now known by this name, but at the mouth of the canyon lies the present little town of Canyon Ferry and the power house of the Missouri River Power Co. The district immediately above Canyon Ferry has been one of the famous gold mining camps of the West, the discovery of gold having been made here in 1863. Placer mining is the more common way in which mining has been carried on, and it can be seen to-day to a limited extent within a mile or so of the power house.

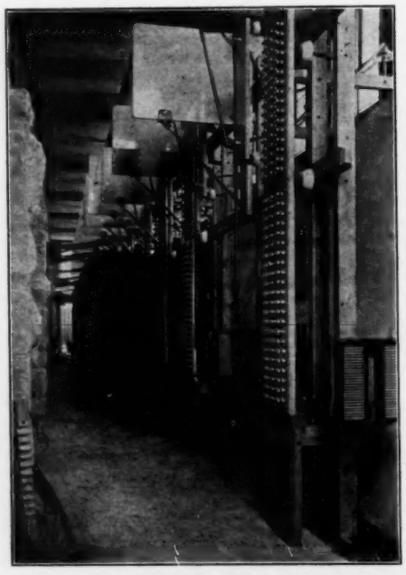


Fig. 3. Room for Step-Up Transformers; Lightning Arresters, High-Tension Switches, Etc., in Foreground.

At the mouth of the canyon a dam has been thrown across the river, about 480 ft. in length and designed to give a 30-ft. head of water. The location of the dam at Canyon Ferry had enabled the company to take advantage of a low-lying valley just above the entrance of the canyon, in which to hold at all times a large volume of water in reserve. At the upper end of the canyon the water spreads out over this valley, forming a lake about seven miles long by two to three miles wide. The canyon by which the water comes to the power house is from 400 ft. to 700 ft. wide and less than half a mile long. The water in it does not freeze over in winter, and although the lake above freezes over, water flows to the power house as free from ice in winter as in summer. The amount of water in the river at this point is considered sufficient to develop 10,000 HP. the year around.

The project for a power plant at Canyon Ferry was first started about ten years ago. The men who probably have taken the most continuous interest in the proposition are Mr. Barton Sewell, of New York city, and ex-Governor Hauser, one of the pioneers of Montana and more thoroughly identified, probably, than any other living man with her history and interests. About four years ago the decision to carry out the work at Canyon Ferry took definite shape and work was started on a plant of 4,000 HP. This plant consisted of four 750-K-W. 550-volt two-phase Westinghouse generators, driven by Dayton Globe Iron Works water-wheels, with two 90-K-W. exciters, driven by independent wheels. The current from these generators was raised by eight oil-cooled transformers from 550 volts to 10,000 volts and sent to Helena and East Helena, 20 miles and 14 miles away, respectively. At Helena the current was used after transformation to 2,200 volts for driving induction motors direct-connected to arc light machines supplying city lights and for distribution for general incandescent lighting. Two rotary converters, furnishing current to the street car system of the city, were also supplied. At East Helena the current was used mostly for driving induction motors in the large smelter located there and for general lighting about the works. One line from Canyon Ferry also furnished power and lights to a large ore concentrator between Helena and East Helena, known as the Peck concentrator. The line between Canyon Ferry and Helena consists of but one pole line, carrying, however, four independent circuits—one to East Helena, one to the Peck con-

centrator and two to Helena, one of the latter for lighting and the other for railway work.

In the fall of 1900 work was begun at Canyon Ferry with a view of making a very considerable extension of the company's plant, the proposition being to enlarge the plant to a capacity of 10,000 HP. by putting in additional generators, with exciters, transformers, etc., and to extend the service to Butte, Mont., where it was expected that

FIG. 4. POLE LINES FOR LONG DISTANCE TRANSMISSION OF MISSOURI RIVER POWER CO.
(The two lines on the left carry a 50,000-volt current to Butte; the pole line on the right carries 10,000 volts to Helena.)

all the power the company might furnish could be sold. To this end the company has installed six additional 750-K-W. Westinghouse generators, with the necessary transformers, exciters, etc. These generators are of the same size and voltage as the first four, but are three-phase instead of two-phase. The water-wheels are 45-in. horizontal McCormick wheels, furnished by the S. Morgan Smith Co., of York, Pa. All generators in the power house are direct-connected to the wheels, flexible couplings being used throughout. With the new generators there was also installed a 225-K-W. 150-volt exciter, driven by a separate wheel and a 115-K-W. 150-volt exciter, driven by an induction motor. To make the plant uniform throughout, the four old generators have been overhauled and changed from two-phase to three-phase. Fig. 1 shows the row of generators, those in the foreground being new ones and the last four being old machines. Each water-wheel has its own governor, all the new and one of the old wheels having Lombard governors, and the remaining old wheels Replogle governors.

The switchboard gallery, shown on the right in Fig. 1, extends the whole length of the building, and besides carrying the switchboard, carries also twelve 550 to 10,000-volt oil-cooled transformers for the Helena and East Helena service, as well as a plug-board for connecting these circuits, as needed under various conditions. The offices of the company will be located on the floor extending across the building at the end from which the view is taken.

The main switchboard and exciter switchboard, shown in Fig. 2, are both relatively simple boards in design, but massive and substantial in construction. The main board is 47 ft. 4 ins. long and consists of 17 panels of blue Vermont marble, 2 ins. thick. The weight of the board complete is about 20 tons, the copper alone being one-half of this weight. The general arrangement is as follows:

The first five panels at each end are generator panels. The next two panels are feeder panels, and are intended for use with the 550 to 10,000-volt transformers. The eighth panel from the end on each side supplies a bank of transformers, 550 to 50,000 volts, for the Butte lines. The middle panel is a junction panel, so that any set of bus-bars on the two ends of the boards can be thrown together, there being three sets of bus-bars on each end of a board. The instruments mounted on the board consist of eight 750-volt A. C. voltmeters, one for each set of busses and one at each end for the machines, independently of the busses; 10 direct-current field ammeters; 28 A. C. ammeters, with 16 indicating polyphase watt-meters and six recording polyphase watt-meters. The recording watt-meters are behind the board. The exciter board consists of four panels of blue Vermont marble, similar to the main board, one for each exciter, with two sets of bus-bars. All field rheostats are mounted under the gallery floor, and are controlled by hand wheels, the shafts of which come up through pedestals in front of the boards.

The feature distinguishing the Missouri River Power Co.'s plant from all other transmission plants is the high voltage employed on its new lines to Butte. This is 50,000 volts, which is higher than is in use commercially on any other plant at the present time. The distance by pole line from Canyon Ferry to the Butte substation is 65 miles, the route corresponding nearly with that taken by the Great Northern R. R. between East Helena and Butte. The line starts out at an altitude of about 4,000 ft. above sea-level at Canyon Ferry and gradually rises until it reaches an altitude of 7,300 ft., where it passes over the Great Divide, a few miles east of Butte.

The line itself consists of two lines of poles about 50 ft. apart, the cables being arranged in

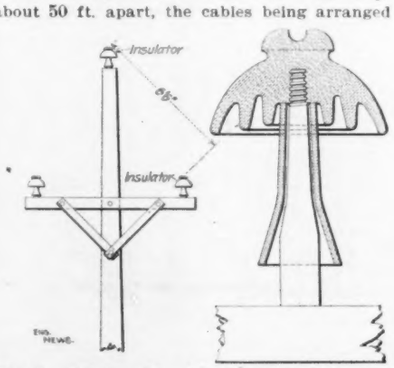


Fig. 5. Details of Insulators and Spacing on Pole.

an equilateral triangle, with a spacing of 78 ins. between centers, as shown in Fig. 5. Each line consists of three seven-strand copper cables, each cable having a cross-section of slightly over 106,000 c. m. These cables are transposed five times between Canyon Ferry and Butte. The average distance apart of the poles is 110 ft. Fig. 5 shows a cross-section of the insulator used on the line, together with the glass sleeve fitting over the pin below the insulator. It has been found, after making exhaustive tests, that a thoroughly dry oak pin of the length used in this installation, boiled in paraffin, will readily hold up alone under 50,000 volts. Hence the object of the glass sleeve below the insulator is to keep as great a length as possible of the pin dry under all conditions of weather.

The transformers at each end of the line consist of six 950-K-W. oil-insulated transformers, with water cooling coils in the cases. Those at Canyon Ferry transform from 550 to 50,000 volts, and at Butte the step-down transformer is made from 50,000 to 2,200 volts. The secondary circuits at Butte consist of 600,000 c. m. bare copper cable. All electrical apparatus in the plant was furnished by the Westinghouse Electric & Manufacturing Co., of Pittsburg.

The general offices of the Missouri River Power Co. are at Helena, Mont., and the New York office is at No. 71 Broadway. The officers are: President, Barton Sewell; Vice-President, W. S. Gurner, Jr.; Secretary and Treasurer, H. Suhr; General Manager and Chief Engineer, M. H. Gerry, Jr.

A STEEL AND CONCRETE COAL STORAGE PLANT.*

By Franklin M. Bowman,† Jun. M. Am. Soc. M. E.

It is the intention in this paper to describe the coal storage plant of the Lowell Gas Light Co. Lowell, Mass., and we shall also touch on the general construction of such plants.

Previous to the building of the new storage plant, old shallow wooden sheds were used, some of which were very antiquated; no modern system of conveying machinery of any kind was used, and the cost of handling coal was quite high. When it became evident to the management of the gas company that large improvements would have to be made in all parts of their plant in order to reduce the cost of manufacture and to increase the output, they were at first inclined to allow the storage buildings to remain as they were, except that coal handling machinery over the old storage was proposed. Having in mind, however, their probable future requirements and considering the limited space they had for remodeling and extending the other parts of their plant, they finally decided to put up a large modern and substantial storage plant, to hold 25,000 tons, about twice the previous capacity.

It will be noted by Fig. 1 that the coal storage building runs parallel to the Boston & Maine R. R., the track immediately adjoining the shed being on the gas company's property. This arrangement allows ten cars to be placed on this siding at one time, and with the unloading hopper in the middle of the length of the building one-half of these cars can be loaded, so that unloading and moving of cars can be carried on continuously, without shifting engines. There would have been some advantage in running the building at right angles to the position decided on, as, with one end of the building against the railroad siding, the coal conveyor would have a straight run, so that it would not be subject to the extra wear and tear, and require the constant extra power necessary to pass round the turns of the tunnel leading under the unloading hopper. Also under this construction the concrete shaft in the centre of the building would not be required. It was necessary, however, to locate the building in the position decided on because they could not disturb the present coal sheds and retort house, as it was necessary to run them continuously while the new buildings were being constructed, and, further, the general scheme required the space of the old coal sheds for other improvements.

In the design of the plant, every effort was made to obtain not only a useful and permanent but handsome structure, if a coal storage can be called handsome. It is a steel frame structure with concrete walls, foundations, and floor and with a tile roof resting on steel purlins. It is fireproof throughout, well ventilated and lighted, protected as much as possible from corrosive influences and arranged so that the pocket can be expeditiously emptied should there be fire from spontaneous combustion, or other causes. The steel truss is braced from the outside of the building with the main columns vertical; with this construction, these columns, with the concrete wall, form the bulkheads for the coal; the inclined back leg, forming the brace at each column, is outside of the storage and supports the overhang (see Fig. 2).

A further reason for the use of this construction is that an inclined floor, with a tunnel in the center of the building, was required, and these conditions made it impossible to put in tie rods across the building to unite the bases of the main columns, and thus take more of the wind strains and the pressure of the coal against the sides of the building.

The shallow truss with bottom chord parallel to the top

*A paper presented at the Boston meeting of the American Society of Mechanical Engineers.

†Structural Engineer, Riter & Conley Mfg. Co., Pittsburg, Pa.

chord makes it impossible for the coal to reach the truss at any point, while the channel tie across the center of the truss, near the ridge, forms a support for the conveyor. It may be noted that the building is without a ridge strut, but the two girders on either side of the ridge answer the purpose, and at the same time form a support for the conveyor, as well as a guard for the foot walk. The shallow inclined truss, with the tile glazed roof, together with the concrete walls and floor, gives the inside of the building a neat and substantial appearance, while the overhang on the sides, together with the tile roof, and the octagonal ends makes the exterior appearance pleasing.

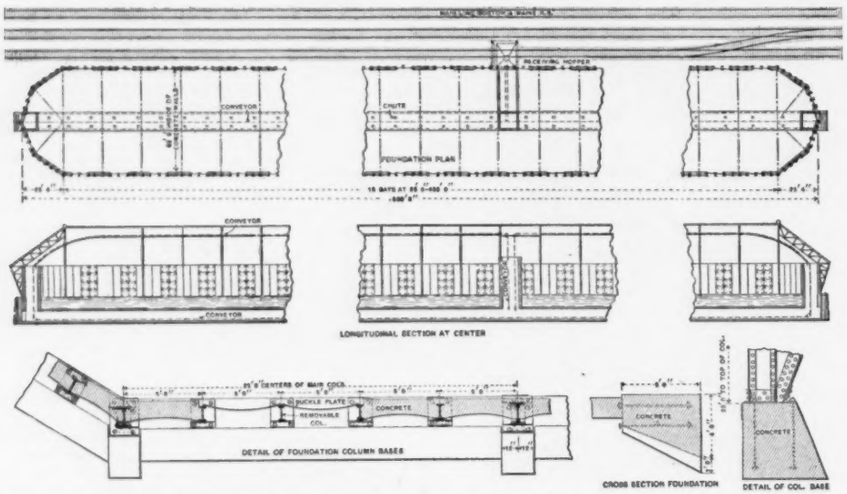


FIG. 1. PLAN AND SECTIONS OF COAL STORAGE PLANT FOR THE LOWELL GAS LIGHT CO., LOWELL, MASS.

The floor and foundations of the structure are made of concrete, the foundations having an inclined back wall slanting away from the building. The building is so designed that the main columns have no horizontal thrust at the base, but the small intermediate columns have the thrust of the coal at their base, thus taking care of the pressure of the coal against the sides of the building.

The roof is covered with Ludowici tile,* the finish of the tile being what is known as non-glazed or semi-porous. Except for its expense, glazed tile would be satisfactory for this structure, because any sweating and dripping inside of the building would do no harm. Unglazed and semi-porous tile is necessary in such buildings as a power house or machine shop, so that there may be none of this dripping. The tile does not, as might be expected, freeze and crack in cold weather from the absorption of water. During a cold spell last winter, lasting almost two weeks, the shed became covered with ice and snow, mostly ice, to an average depth of four inches, but the tile has, apparently, not be injured.

Light is obtained principally through skylights in the roof, made of glazed tile of the same form and size as the ordinary tile and laid on the roof in the same manner. Additional light and ample ventilation is obtained from the opening between the roof and the top of the wall.

It is to be noted that the coal in this building is stored on the ground and not in an elevated structure; wherever possible, it would seem that coal should thus be stored, and where this is impractical it is important that the inside of the storage be entirely lined with concrete, so that no part of the supporting steel work is exposed to the corroding action of the coal.

Public attention has recently been called by Mr. Sooysmith to the possible danger due to corrosions in tall steel frame office buildings, but danger from this source is largely accentuated in a coal storage, with its sulphur and other corrosive substances. For this reason, where a permanent and costly structure is to be built, as is usual in the case of large power houses, coal bins lined with steel plates should not be used, as they are liable in time to become a menace to life and property.

In the case of Lowell, all main columns, and as far as possible the intermediate columns, are entirely covered with concrete. The steel work which is exposed cannot be reached by the coal, can readily be painted and is made throughout of heavy material.

The coal storage pockets of the power houses of both the Manhattan Ry. Co., and the Metropolitan St. Ry. Co., of New York, are steel structures, and are constructed along the lines indicated (Fig. 2), the steel framework being covered with concrete. The Manhattan Ry. Co. adopted the Columbian system, which consists of putting in small special beams about 2 ft. apart, thus allowing the main beams to be spread further apart than otherwise. They are thus able to use a less thickness of concrete and effect a saving in weight, cost and space. Another similar and very good construction in use is either expanded metal or wire netting covered with concrete. The essential point is to have the steel framework, and especially the joints, entirely surrounded and imbedded in concrete, as under these circumstances steel will not corrode.

On account of the limited space on the property for the coal storage plant, it was necessary to keep the building narrow, and consequently coal had to be piled to the considerable depth of 40 ft. It was, therefore, thought best to design the pocket so that it could be promptly emptied in case of fire from spontaneous combunstion or other causes. With this in view the floor was given a pitch of 15° towards the tunnel in the center of the building, so that the two sides can be easily and well drained of coal by the conveyor. In order, however, to expedite the removal of coal in case of fire, two panels in the sides out of every five were made of removable steel buckle plates with a movable column in the center; these can be unbolted and moved promptly and coal can be taken out of this 10-ft. wide opening.

In connection with this matter of spontaneous combustion, upright wrought iron pipes were placed in a row along the center of the building. These were installed by the superintendent, Mr. T. H. Hintze, with a view to determining, approximately, the temperature of the coal by means of a thermometer held at the upper end of the pipe. In this manner any coal in the storage which shows signs of becoming heated can be conveyed to the retort house and used.

Reverting to the machinery, the conveyor is of the gravity bucket type. The buckets are 18 ins. wide by 24 ins. long, pivoted in the chain in such a manner that while they maintain themselves normally in an upright position, they can turn through a complete revolution. The chain is composed of double flat links of steel, and the conveyor moves about 40 ft. per minute.

The driving mechanism is located in the tr[illegible] and is operated by two 6 × 8-in. steam engines of non-freezing type. This mechanism is peculiar, from the fact that instead of sprocket wheels the chain is driven by pawls, thus reducing the wear and imparting a smooth and uniform motion. The machinery receives the coal from the hopper under the railroad tracks, cracks the lumps to a uniform size and carries them without transfer to [illegible] part of the building. When the new retort house is completed coal will be taken from any part of the storage and will be delivered to a separate conveyor leading to the retort house. It is to be observed that all the functions of receiving, cracking and rehandling, are performed by the conveyor, the receiving section of which can be detached when rehandling coal from storage. The coal is delivered into the conveyor by means of adjustable cast-iron valves, which have no sliding surfaces. When the valves are closed, the column of coal above does not tend to open them. Before the valve is open the filler which runs up and down the length of the tunnel, is placed in position under such valve; the coal then passes through the filler to the conveyor.

In general it is to be noted that the plant has been designed with a view to securing a durable, neat and suitable structure, and no reasonable expense was spared to obtain this result. The work was carried on most expeditiously, especially considering the difficulties in connection with the foundations, where sewers, pipe lines and rock blasting had to be contended with. Ground was broken in March of last year and the plant was completed in September, so that five months was the time required for its construction.

*Eng. News, Vol. July-Dec., 1899, p. 78.

A CONTINUOUS ELECTRIC BLUE-PRINTING APPARATUS

The application of the electric light to blue-printing has wellnigh worked a revolution in the blue-print department of many drafting rooms, especially those located in districts where cloudy weather is prevalent, or in cities where smoke obscures the sun much of the time.

We illustrate herewith an apparatus which appears to us to mark a further large advance in the economical production of blue-prints, and which involves a radical departure from both the flat frame and the glass cylinder type of blue-printing apparatus. This machine dispenses entirely with the use of glass (a point which appeals to those who have had to pay bills for broken plate glass), and also with all clamping devices for holding the work in position. Instead the blue-print paper and the tracing are firmly held against the convex surface of a revolving drum by a traveling transparent apron, which moves at the same rate of speed as the drum. This rate of speed is so slow that the printing takes place while the print is passing under the rays of an electric light, arranged to concentrate its illumination on the rear face of the drum.

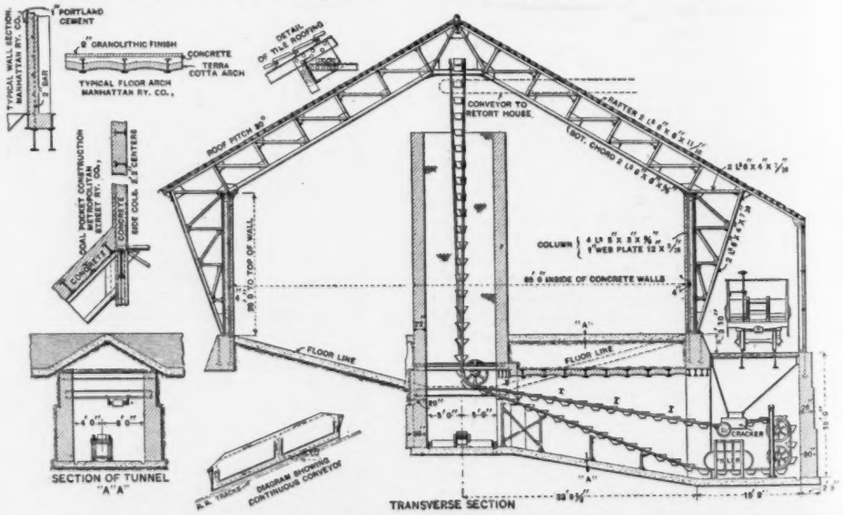


FIG. 2. SECTIONAL VIEWS OF LOWELL COAL STORAGE PLANT AND DETAILS SHOWING METAL PROTECTION OF METAL IN NEW YORK POWER STATIONS.

The operation of the machine will be readily understood from the perspective and sectional views herewith presented. As there seen, the machine has a hardwood frame, which supports the drum or cylinder. The drum is made to revolve at any desired speed by simple mechanism. The time of exposure, which may be from 20 seconds

upward, is adjusted by moving a lever on the speed regulator. Mounted on top and in front of the machine is a roll carrying the transparent traveling apron, which keeps the tracing in tight contact with the sensitive printing paper and is then automatically wound on a roll at the bottom of the machine. After exposure, the tracing and sensitive paper drop out at the bottom. The light chamber at the rear is so arranged as to throw the light upon about one-third of the drum surface.

Any first-class photo-engraver's lamp can be used, and the makers recommend three lamps in a machine 42 ins. wide. With narrow tracings, one or even two of the lamps may be shut off, or all three may be concentrated on the narrow path and the speed of the machine increased. With lamps of 25 to 30 amperes several yards of prints can be turned out per minute. The driving mechanism can be operated from existing power by means of a belt, or a small electric motor can be installed on top of the machine, as shown in the cut. Two sizes of the machine are now built, 30 ins. and 42 ins. wide on the drum; but the larger drum is recommended, as it costs little more than the 30-in., and the additional width is often convenient in handling large tracings. The 42-in. machine takes up a floor space of 4 ft. × 4 ft. 2 ins., and stands 4 ft. 8 ins. high.

This machine was originally developed to meet a demand for continuous prints from very long tracings. The limit of practicable size is reached with glass printing frames at 10 or 12 ft. The manufacturers of the machine, the Spaulding Print Paper Co., of 44 Federal St., Boston, state that demands have been made upon them for prints 40 ft. to 60 ft. long. With the old 6-ft. printing frames these 40-ft. tracings would require seven distinct exposures, with all the necessary preparation and manipulation, and the product would come out in separate sections. With the new machine the resulting print is continuous, and it can be made in one-sixth of the time.

While the machine has an evident advantage in handling very long prints, and, in fact, all large prints which require printing frames of unusual size, it is also found to be advantageous for the ordinary run of blue-printing work. With the ordinary blue-print frames the work of taking in the frame, reversing, unclamping, removing print and tracing, putting in new ones, clamping up again, reversing and running out for exposure takes as long or longer than the printing process itself, so that the printing frames are idle half the time, no matter how the work may be rushing. With this machine the printing goes on continuously; the operator simply feeds in the tracings and blue-print paper. Where a large number of very small prints are to be made, the tracings can be fed in on top of a continuous roll of blue-print paper. The company which has developed the machine has been engaged in the production of blue prints in a commercial way for many years, and the machine was devised as a result of their experience. They have had it in use for several months with most satisfactory results.

While the machine is shown equipped for electric light printing, it can also be arranged to use sunlight, or can be mounted on a truck to be run outdoors in fine weather and run in to use electric light when the sun is obscured. The fact will also be appreciated that it takes up less room in proportion to its capacity than any blue-print apparatus on the market.

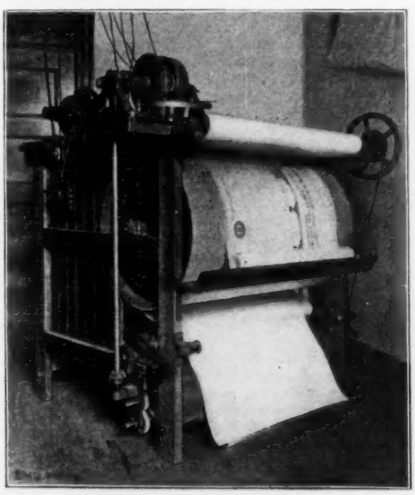


Fig. 1. Perspective View.

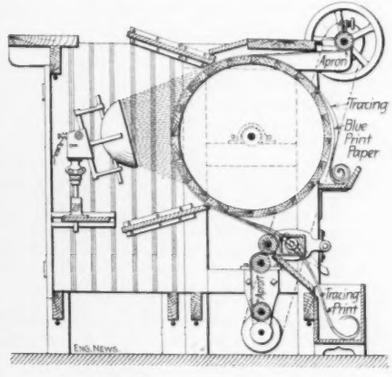


Fig. 2. Cross-Section.

THE FEDERAL ELECTRIC BLUE PRINTING MACHINE.
The Spaulding Print Paper Co., Boston, Mass., Manufacturers.

THE ATLANTIC AVENUE STATION OF THE BOSTON EDISON ELECTRIC ILLUMINATING CO.*

By I. E. Moultrop and R. E. Curtis,† Members Am. Soc. M. E.

The original plans for this station contemplated one boiler room—the cross wall at the chimney being removed—free communication between the engine rooms by large open archways, and a switchboard on an open gallery in the engine room. In determining the general scheme of the enlarged plant, among the considerations which presented themselves with special emphasis were (a) the desirability of locating the entire switching and regulating plant in a central and convenient position, and (b) the importance of disposing it and the various parts of the steam plant in such a manner that no conceivable accident short of an earthquake or a bombardment could bring about a condition of affairs which would compel the shutting down even temporarily of the entire station. This led to the adoption of the subdivided type of station shown, having two distinct engine rooms, two fire rooms and a "switchboard" room, communicating conveniently with each other, but capable of instant and complete separation each from the other, so that not only in case of fire or a steam explosion should it be possible to confine the effects to the room in which it originated, but it is made possible for the electrical operator to remain comfortably at his post and to make such manipulations as will protect the generating apparatus involved, and will transfer the load to that portion of the station which can still be kept running.

Experience had shown that the switchboard installation required to meet the demands on the station would be considerably greater than had been supposed nearly a decade earlier. This, together with the desire to protect the operating center of the station to the fullest possible degree, and with the feeling that wise policy dictated generous working spaces about the apparatus, led finally to the enclosure of a part of the original engine room for this purpose, and its isolation from the rest of the station by substantial brick walls extending from the basement floor to several feet above the station roof. The original board thus became the nucleus of the larger installation, and its existence in this position naturally led to the selection for the operating room of this central location convenient to both engine rooms. Communication with the engine room for giving and receiving orders is most satisfactorily established by an installation of Cory signals of the type commonly used on shipboard, there being two sets of instruments in connection with each engine room, one set showing the order and the other the number of the machine to which it applies. There are also small windows, protected by fire shutters, opening into the engine rooms, for observation and emergency communication, and small fireproof doors for entrance and exit. It would seem, therefore, as though the apparatus and operators in this room should be practically proof against injury or disturbance by accidents in the station.

The structure of the room and its various floors is fireproof. There are at present two floors above the basement, and girders are in place for a third, at the level of the gallery in the new engine room, should it be needed in the future. All these floors and the treads of the stairways are of slate, supported by steel framework.

The manufacturing board is located on the first floor, and to it are connected the various generators and the tie lines to other stations. The term "board" is applicable to this installation only in a conventional way. At present there are two rows each of 20 posts on one side of the room, on which are mounted motor-operated switches of 3,500 and 7,000 amperes capacity. One of these rows is used for positive and the other for negative switches. The busses each consist of three 8-in. × ¼-in. bars, giving a total cross-section per bus of 12 sq. ins. These switches were built specially for the Edison Electric Illuminating Co., and were the first of their kind.

The field regulating rheostats for the generators are set close to the generators and operated by motors controlled from the operating table. This obviates a long extension of the field circuits to the switchboard room, thus reducing risk of trouble with generators; and in case of accident to the control circuit, hand regulation may be resorted to. The entire system of distant operation and control makes possible a very compact arrangement of switches and regulating apparatus, especially as regards ground area, brings everything under easy observation, facilitates prompt operation, and greatly reduces the labor of it.

The feeders and tie lines leaving the switchboards and the main leads from the generators in No. 2 room are of cable, the older feeder cables being carried through the station in iron ducts under the gallery, and the later installations through vitrified ducts in the engine room floor and the basement of the switchboard room.

The other large conductors within the station, including the booster leads, and the connections to the generators in the old station are of bare copper, each being made up of several thin copper bars separated by air spaces. This is a type of construction which has recently been adopted in several places in the company's different stations, and has proved quite satisfactory. It is not affected by atmospheric conditions which would be quite trying to cables, radiates heat effectively, is less liable to a disabling mechanical injury, can be readily inspected, and is comparatively economical to install. In case of the generator leads, the supports are somewhat different from those used elsewhere. Ætna "barn type" hangers are used, being mounted on a steel framework, which is in turn secured to the floor framing above. As a protection against mechanical injury, each group of coppers is enclosed in a cage of stiff galvanized wire netting, with a sloping roof of sheet steel. The booster leads are supported on slotted slate bars resting on an angle iron structure.

MAIN STEAM PIPING.

The original steam-piping installation was arranged upon a ring system, the boilers delivering steam into two headers which extended lengthwise of the room and which were tied together by cross-mains; the latter were extended into and lengthwise of the old engine room, and there again joined by tie connections crossing between the various engine foundations. From these latter the branches to the respective engines were taken. Valves were lavishly distributed over this system, making it theoretically possible to interchange to almost any desired extent. The construction and arrangement were, it was believed, representative of the best practice prevailing at the time of its installation; but although it had been operated for a number of years successfully and with little trouble, it was considered, in the light of advances in construction and experience, and in view of the use of superheated steam, that it was not the best for the new station, and fresh plans were determined upon for both parts of the station.

It was believed that the number of units in the station had reached such a point that the elaborate system of interchange of the old piping was no longer of practical value, and involved unnecessary complication. It was further held that the ideal arrangement for a large station with similar units would be one in which each engine was connected in the most direct manner possible to a corresponding group of boilers, these various units of piping being interconnected by balance pipes to such an extent only as would equalize pressures, permit taking out individual boilers as needed for cleaning and repair, and make it possible to run any engine or boiler unit in connection with the boiler or engine units next adjoining, in case its own complementary unit was temporarily entirely out of service. In case the engines are of uniform type and power, and the ground plan such as to allow a symmetrical layout, this ideal should generally be easy to attain; otherwise an approximation only can be made.

In this station the boilers are connected together in

*Condensed from a paper read at the Boston meeting of the American Society of Mechanical Engineers.

†Engineers, Edison Electric Illuminating Co., Boston, Mass.

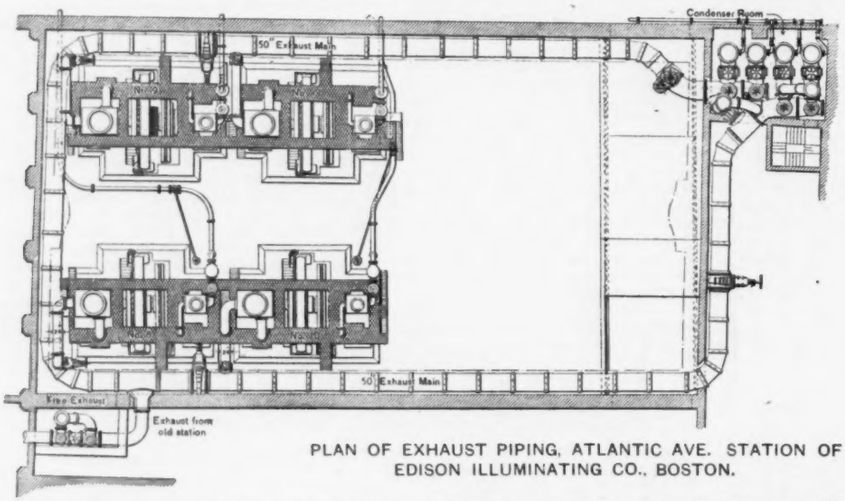
groups of about four, each group discharging through a transverse main into one of the series of headers which run lengthwise of the station along the wall separating the engine and boiler rooms. These headers are connected each to those next adjoining by means of 8-in. loops, and from the headers are led the branches to the engines. In case of the larger engines in No. 2 engine room, each branch supplies one engine; while in case of No. 1 engine room the two mains are of slightly larger size, and each supplies a group of smaller engines, the three 1,200-HP. engines being supplied by one and the four 650-HP. engines by the other of these.

The auxiliary machinery is supplied from special 6-in. mains, conveniently situated, and fed from the principal mains at various points. All high-pressure lines are drained by "Holly" systems, one being installed for the old station and one for the new. The distributing mains, or "headers," are 12 ins. in diameter and limited to about 50 ft. in length; consequently expansion is kept down to a moderate figure, which is also reduced by anchoring each header near its center of length. This practice is also followed in case of the longer branch pipes, the expansion being compelled to take place in a predetermined direction, and such allowances being made in the lengths of individual pieces as will reduce the stresses on the mains when in normal working condition. The former roller bearings have been abandoned for sliding bearings, the friction on these being most efficient in eliminating vibration, while not being sufficient to interfere with expansion. In a few cases where the grade of a horizontal pipe was subject to change of temperature, compensating hangers on the steelyard principle have been used, and the reaction necessary to counteract vibration obtained by an arrangement of semi-elliptical springs adjusted to take just enough weight to steady the pipe without exerting an excessive force in opposition to the forces of expansion.

CENTRAL CONDENSING SYSTEM.

A central condensing system for the new portion of the station was determined upon, in the belief that it offered the best opportunity of developing the space in the main station for generating purposes, and would give the most compact and conveniently operated condensing plant with a satisfactory economy. Advantage was taken of an otherwise unoccupied area included between the engine house, boiler house and the adjoining buildings for the installation of the condensing machinery, so that no floor space is taken up by it in the station proper. The complete plant will include four air pumps with jet condensers and feed-water heaters in the condenser room, and a riveted steel exhaust main extending from the condenser room in either direction and entirely around the new engine room. The first installation, made in 1900, consisted of one-half the condensing machinery (two complete units) and that part of the pipe extending around the easterly and northerly sides of the room and to a point beyond No. 8 engine. The remainder of the condensing machinery and of the main and a connection to engines 6 and 7 in the old engine room are to be installed during the current year. Therefore, in describing it, the entire system will be considered as completed.

Each condensing unit is of 5,000 HP. nominal capacity, and consists of a vertical twin-beam Blake air pump with 16-in. steam cylinders, 44-in. water cylinders, and 24-in. stroke, with a jet condenser attached. Circulating water is taken from the harbor through a sluice 7 ft. wide by 11½ ft. high, with its floor 8 ft. below mean low-water line, and is returned through a 48-in. cast-iron pipe. Above each condenser, and connected to it by 40-in. cast-iron piping, is a vertical Goubert feed-water heater containing 1,333 sq. ft. of heating surface. The exhaust steam reaches the heater from the engines by means of the main above mentioned, which is 50 ins. in diameter,



PLAN OF EXHAUST PIPING, ATLANTIC AVE. STATION OF EDISON ILLUMINATING CO., BOSTON.

Screwed flanges were discarded in favor of steel flanges welded on, and the use of copper for high-pressure work definitely abandoned, it being believed that these steps would not only reduce the number of joints liable to leaks, but would be decidedly in the direction of more uniform, flexible and trustworthy materials. The former policy of using air-furnace gun iron for fittings has been continued, great care having been taken to choose such forms and dimensions at the junctions of flanges and branches with the bodies of the castings as will tend to soundness of casting and easy flow of steam. The company's specifications call for an iron of from 28,000 to 32,000 lbs. tensile strength, and a very tough, compact and reliable material is obtained. Joints are tongued and grooved, made up with thin corrugated copper gaskets and heavily bolted.

A special feature of the piping is the installation, in connection with all valves controlling the branches from the boilers or other mains supplying steam to the headers, of auxiliary valve stems leading off through solid brick walls to points from which they can be operated regardless of conditions at the valve. This makes it possible in case of a disabled steam line to positively cut off the break in the quickest order. Stop-check valves in each boiler branch also give additional protection to the fire room. It will be noted that the change of pipe scheme made it possible to reduce the pipe sizes over those of the former system, 12-in. being the largest size now used against 15-in. in the old lines. The branches from the boilers were reduced from 8-in. to 6-in. and other lines kept to moderate sizes. Inasmuch as heat units at the engine were what was sought, the reduction in radiation was held to be of more importance than a slight drop in pressure, although drop and velocity were kept within reasonable limits. Large receiver separators at the engines, with enlarged connections to the cylinders, equalize the fluctuations in branch pipes due to cut-off.

each leg being connected to the heaters of two condensing units, and the two legs interconnected by a 40-in. valve.

Chapman gate valves are placed in the main in such positions as to divide it into three sections, to each of which will be ultimately connected the exhaust from two of the six engines forming the full equipment of this room. Each section is provided with two 24-in. Gallison relief valves discharging through galvanized iron risers, respectively 30 and 36 ins. diameter, which terminate above the roof in Sturtevant exhaust heads.

The portion of the main within the condenser room is of cast iron with suitable outlets for connection to heaters and relief valves, while the principal portion of the main is a riveted steel pipe. This latter is, perhaps, the most interesting feature of the condensing system, as it is only by the most careful design and workmanship that a riveted pipe can be depended on for such service. So far as known, there was no precedent applicable to the case, but after consulting with parties experienced in boiler construction, it was concluded that a satisfactory pipe could be built, and the contract was executed by a local concern.

The main is made up of ⅜-in. flange steel plates, all joints being butted with outside straps, and rivets being countersunk and driven flush on the inside. Roundabout butt straps are 9 ins. by ⅝-in. and longitudinal straps 5 ins. by ½-in. Longitudinal seams are single riveted, and roundabout seams double riveted, all rivets being ¾-in. diameter in drilled holes, and pitched about 2¼ ins. c. to c. All seams were calked inside and outside, and great care was taken in cleaning, planing, rolling, and fitting plates to secure perfect tightness.

Each course is made of one plate, the longitudinal seams being about 20° either side of the vertical center line at the top of the plate. Courses generally run from 7½ to 8 ft. in width, although a few are as wide as 9 ft. 2 ins. Bends were also riveted up, the right angle (approximately) bends being made in four courses, each with a radius at the center of the pipe of about 9 ft. Cast-iron companion flanges for the valves, manhole frames for each section, and nozzles for the branch exhaust risers were carefully fitted and riveted to the pipe.

The greater part of the pipe proper is supported on cast-iron saddles riveted to the under side of the main, and resting upon cast-iron bearing plates, which are supported in turn to the engine-room gallery framework. These supports are placed about 16 ft. apart, and each provides about 1½ sq. ft. of bearing surface. At the valves heavy cast-iron saddles are provided, fitted under the flanges and resting upon "I" beams. The main is anchored in place at the condenser-room ends, and at the opposite end of the room it is so confined that movement lengthwise must take place in either direction from the center; otherwise it is not confined, except by the friction of supporting plates. The actual expansion in a length of about 135 ft. was 1¼ ins. with one engine running non-condensing, which reduced to ⅞-in. when running condensing.

Each condensing unit comfortably cares for two engines. The loss of vacuum between pump and engine is small, and if allowance were made for friction in the heater and in the branches from the individual engines, the drop in the main would undoubtedly be negligible. A somewhat less vacuum was to have been expected with a condensing system like this than from condensers close to the engines, especially with the central system loaded only to a fraction of its capacity; but in practice this loss has not appeared to be serious, and it is believed to be outweighed by the expense, complication, and inconvenience of the pipes and connections which would otherwise have been required in the engine room, not to mention the advantage of releasing valuable space there for other uses by placing the condensing plant in an otherwise useless area. So far the main has remained bare without being troublesome, but it is possible that when the full projected engine equipment shall be installed, it may be necessary to apply non-conducting covering.

SUPERHEATING.

Beginning with the installation of 1899, all new boilers have been equipped with Babcock & Wilcox superheaters, designed to superheat from 100° to 125°, and applied in the usual manner in the central pass to the boiler. There are therefore at present 4 of the 11 boilers in the old station so equipped, together with the 4 in the new station, and the boilers to be installed this year will also be provided with superheaters.

It is unfortunate that conditions are such as to prevent the exact determination of the gain realized from their use. Comparative results, based on occasional tests of the various engines, indicate an increase of economy varying according to the distance from the boilers and the quality of the steam furnished. As there are always several boilers in service in the old station, which have no superheaters, No. 9 engine (the one nearest the new chimney) is the only one of those installed so far which can be assumed to have at all times the fullest benefit of the superheat. The other engine in the new room (No. 8) is liable to get some of its supply from non-superheater boilers, and has the relative disadvantage of a longer branch from the main. With the usual service combination of boilers, the superheat at the throttle of No. 8 engine ranges from 70° to 80° F., and at the throttle of No. 9 engine from 80° to 100°; while at the throttle of the engines at the street end of the old engine room, where a large proportion of the steam is drawn from non-superheater boilers, and traverses approximately 180 ft. of pipe after leaving the header in the boiler room, there is still a little superheat left, say, 5° to 10° ordinarily, which may occasionally be increased to about 25° under specially favorable conditions.

Probably the best argument for superheat under these conditions is the fact that a considerable and progressive improvement in the economy as gaged by coal used per kilowatt delivered to the switchboard has been obtained as a result of recent installations, a considerable part of which cannot be assigned to any other cause.

However, the following results of acceptance tests on engines No. 8 and No. 9 may be of some interest. They were taken in case of both engines at approximately normal full load, and under practically identical conditions except length of steam supply pipe. Tests A and B were taken with jackets and reheaters in service, and tests C and D without.

Test	A	B	C	D
Engine	No. 8	No. 9	No. 8	No. 9
Average I. HP.	2,267.0	2,201.6	2,239.8	2,215.1
Jacket water, I.HP. hr.	0.825	0.78	...	...
Total water per I. HP. hr. (including above). Actual conditions	12.72	11.57	12.98	11.88
Total water per I. HP. hr. corrected to dry steam at 160 lbs. initial and 26 ins. effective vacuum	12.51	11.64	12.61	12.00
Superheat at throttle, deg. F.	80.2	98.4	78.5	98.4

There was a noticeable improvement in the quality of steam during expansion as compared with earlier engines, but moisure is not yet entirely absent in either cylinder, and there must be a considerable increase in the amount of superheat at the throttle before the reheater between

cylinders can be omitted and saturated steam can be delivered to the condenser.

It is, perhaps, worthy of note that all the compound engines at the station are McIntosh and Seymour engines with their standard valve gear including sliding gridiron valves which have so far proven perfectly adapted to the service.

The superheaters have given no trouble whatever up to the time of writing, nor has there been any trouble with piping or valves on account of the quality of the steam.

MISCELLANEOUS.

ASH-HANDLING.—The handling of ashes at this station has been reduced to a very simple system. They drop from the grates directly into chutes, from which they are drawn off from time to time and teamed way. This manner of disposing of them, never very expensive, may at times, when there is a demand for them for filling, even prove slightly profitable. The standard type of chute for the old station has been a steel-plate hopper lined with fire-brick. For the new boiler room a construction was devised which afforded a capacity equal to one day's production of ashes. It is a masonry structure, supported by a steel framework from the main floor framing, and consists of brick-retaining walls and a sloping bottom of cinder concrete, all lined with firebrick. A rotating gate is provided, specially designed, to economize height. As the ashes fall from the stoker close to the bridge wall, the latter is supported by a set of three 10-in. cast-iron I-beams, and the chute extended back under and somewhat beyond it so as to obtain the maximum capacity.

MOTOR OPERATED VALVES.—While installing the considerable number of large valves (24 to 48 ins.) required in the newer part of the station, it was felt strongly that some means of operating such valves more conveniently, and much more expeditiously than by hand, was a prime necessity. Particularly and from obvious reasons this was felt to be true in regard to the valves controlling the exhausts from the individual engines. Every possible motive power was investigated, but no type could be found satisfactorily meeting the requirements in season for the original installation, and they were put in of the ordinary geared hand types. This matter has, however, been vigorously followed up and two 24-in. valves, equipped with different types of electric operating mechanism controlled from distant points, have been recently built and will be thoroughly tested in service. Enough has already been learned to make it practically certain that all valves 24-in. and over will shortly be motor driven.

RELATION OF RAINFALL TO RUNOFF IN CALIFORNIA.

By J. B. Lippincott, M. Am. Soc. C. E., and S. G. Bennett.*

A study of the available rainfall and runoff data for California watersheds has been undertaken and the accompaying diagrams and tables are here presented as the result of this work.

As the runoff diagram was to be used in estimating the water supply available for various storage reservoirs for irrigation, it was thought best to represent the runoff in acre-feet per square mile. The majority of the discharge reports give the depth of runoff in inches. The accompanying table has been made for converting depth of runoff in inches to runoff in acre-feet per square mile, using the following formula:

Depth of runoff in inches × (0.0833 × 640) = runoff in acre-feet per square mile.

Table for Converting Depth of Runoff in Inches Into Acre-Feet Per Square Mile.

Depth of runoff, ins.	Acre-ft., per sq. mile.	Depth of runoff, ins.	Acre-ft., per sq. mile.	Depth of runoff, ins.	Acre-ft., per sq. mile.
.01	533	.35	18.667	.69	36.800
.02	1.067	.36	19.200	.70	37.333
.03	1.600	.37	19.733	.71	37.867
.04	2.133	.38	20.267	.72	38.400
.05	2.667	.39	20.800	.73	38.933
.06	3.200	.40	21.333	.74	39.467
.07	3.733	.41	21.867	.75	40.000
.08	4.267	.42	22.400	.76	40.533
.09	4.800	.43	22.933	.77	41.067
.10	5.333	.44	23.467	.78	41.600
.11	5.867	.45	24.000	.79	42.133
.12	6.400	.46	24.533	.80	42.667
.13	6.933	.47	25.067	.81	43.200
.14	7.467	.48	25.600	.82	43.733
.15	8.000	.49	26.133	.83	44.267
.16	8.533	.50	26.667	.84	44.800
.17	9.067	.51	27.200	.85	45.333
.18	9.600	.52	27.733	.86	45.867
.19	10.133	.53	28.267	.87	46.400
.20	10.667	.54	28.800	.88	46.933
.21	11.200	.55	29.333	.89	47.467
.22	11.733	.56	29.867	.90	48.000
.23	12.267	.57	30.400	.91	48.533
.24	12.800	.58	30.933	.92	49.067
.25	13.333	.59	31.467	.93	49.600
.26	13.867	.60	32.000	.94	50.133
.27	14.400	.61	32.533	.95	50.667
.28	14.933	.62	33.067	.96	51.200
.29	15.467	.63	33.600	.97	51.733
.30	16.000	.64	34.133	.98	52.267
.31	16.533	.65	34.667	.99	52.800
.32	17.067	.66	35.200	1.00	53.333
.33	17.600	.67	35.733		
.34	18.133	.68	36.267		

*Hydrographer and Assistant Hydrographer, respectively, of the U. S. Geological Survey for California, Los Angeles, Cal.

At the outset many difficulties began to present themselves. The most serious one was that of obtaining measurements of rainfall at the higher elevations. The streams most productive of runoff, and upon which discharge records had been kept, have their sources on the western slopes of the high Sierra Nevada Mountains, where there are few or no inhabitants above 7,000 ft., and consequently no observers of rainfall, but the valuable rainfall records of the Pacific Railway System along the line of railway from Sacramento to the summit of the Sierra Nevada at Railroad Pass offered a clue to solution of this difficulty. In Fig. 1 the mean rainfall and the elevation of the station are plotted as ordinates and the distance inland of the station as abscissas.

The rate of increase of precipitation from Sacramento to Cisco, at the elevation of 6,000 ft., the point of maximum rainfall, seems to be 0.6-in. per 100 ft. of rise. The precipitation above the 6,000-ft. point decreases with the elevation approximately at the rate of 0.4-in. per 100 ft. of rise.

Fortunately, in the Tuolumne River basin, about midway between the American and the Kings River basins, there is another series of rainfall stations, beginning with La Grange, elevation 293 ft. above sea level; Sonora, elevation 1,824 ft.; Second Garrote, elevation 2,900 ft., and Crockers, elevation 4,453 ft. The mean rainfall of these stations plotted as in the above diagram indicates the rate of increase from La Grange to Crockers to be 0.84-in. per 100 ft. of rise. This rate of increase has been taken to hold good up to an elevation of 6,000 ft., and above this the rate of decrease of rise to be 0.4-in. per 100 ft. to an elevation of 9,000 ft. Probably the rate of increase and decrease would be more correctly represented by a curved line, but the data are not sufficient to warrant this.

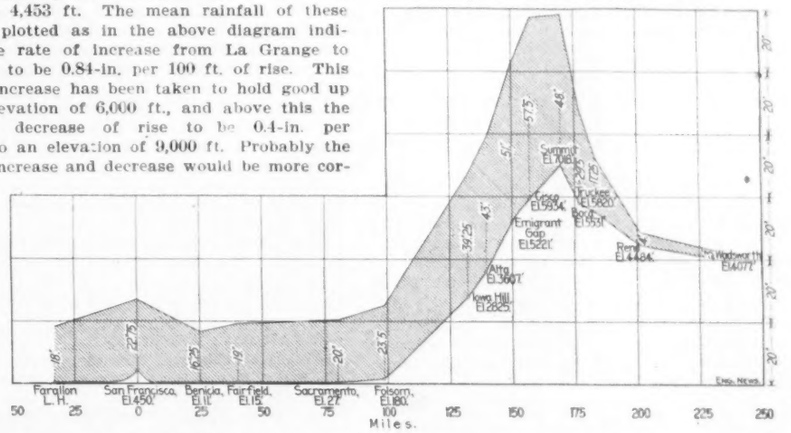


FIG. 1. DIAGRAM SHOWING INCREASE OF RAINFALL WITH RISE IN ELEVATION OVER THE SIERRAS IN CENTRAL CALIFORNIA.

Using these rates of increase and decrease, the mean precipitation for the years 1896-1899 at an elevation of 9,000 ft. in the Tuolumne River basin would be 49.8 ins.; if snow converts into water at the ratio of 8 to 1, the snowfall would be 33.2 ft. at this elevation.

It was found impossible to use the runoff data of the Kern River basin, though it is without doubt the most closely watched stream in the State, and the record is the oldest for any large stream in the State, because of the exposure of the watershed and because of the scarcity of rainfall data. This watershed is bounded on the west for almost its entire length by a high mountain range. Concerning the precipitation on the east slope of this range there is little known beyond the fact that it is very much less than on the western slope.

In 1896 the total runoff from the Kings River basin of 1,775 square miles was 1,871,005 acre-feet. For the same year the runoff from the Kern River basin was 619,630 acre-feet. The ratio of the area of the Kings River basin to the Kern is 1 to 1.32, the ratio of runoff 1 to 0.33, though the higher drainage areas of the streams are contiguous. It was also thought best not to use the runoff and rainfall data for Piru Creek basin, furnished by the Antelope Valley Water Co., because the ratio of discharge in acre-feet per square mile was greater than any other record. There is little doubt about the accuracy of both the runoff and precipitation records, the explanation being that the rainfall observation stations were necessarily situated at so low an elevation that the record did not represent the mean rainfall for the higher portions of the basin.

The runoff and rainfall data of the streams which were used to make the discharge diagram, Fig. 2, will be mentioned in the order from north to south in which their watersheds occur.

SACRAMENTO RIVER BASIN.—The rainfall stations used in determining the mean annual precipitation for the Sacramento River basin were the following: Red Bluff, Rosewood, Redding, Delta, Dunsmuir, Shasta, Sissons, and Ft. Bidwell.

There were absolutely no records for the great interior mountainous and lava country in Siskiyou, Modoc and Lassen counties, comprising more than 5,334 sq. miles of the watershed.

Ft. Bidwell is situated outside of the watershed, on the eastern slope of the mountains that form the boundary, and would probably have a less rainfall than Modoc county. The record was kept there for a period of 22 years, and the mean rainfall is 20.8 ins.

The average rainfall at Red Bluff for a period of 23 years was 23.9 ins.; at Rosewood, for a period of 6 years, 25.63; at Redding, for 24 years, 35.69. The precipitation at these three latter stations was taken to get the average for the Sacramento Valley for the years 1896-1899, during which runoff measurements have been made at Jelly's Ferry. The mean rainfall of the Pitt River drainage area of 5,334 sq. miles, which has an average elevation of 5,000 ft., was taken to be the same as that of the Sacramento basin above Red Bluff.

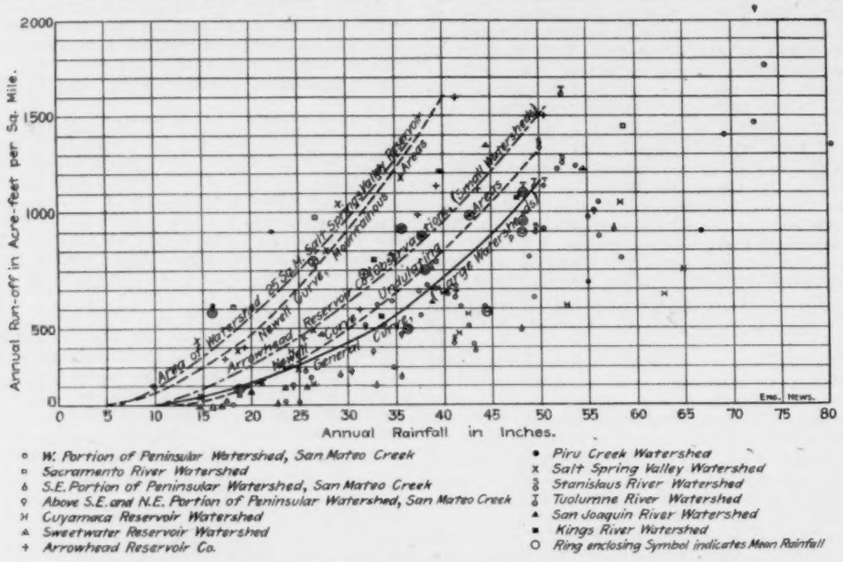
The average rainfall at Delta for a period of 14 years was 62.39 ins.; at Dunsmuir, for 10 years, 57.16 ins.; at Shasta, for 6 years, 53.26 ins.; at Sissons, for 10 years, 32.75 ins. The rainfall at these four stations was taken to obtain the mean rainfall for the mountainous area of the watershed for the years 1896-1899.

SAN MATEO CREEK.—The Spring Valley Water Co.'s record of rainfall and runoff from the watershed of San Mateo Creek is without doubt the oldest record in the State, having been kept for 30 years. In the table given on page 390 of Water Supply and Irrigation Paper No. 38, of the U. S. Geological Survey, no allowance has been made for evaporation from the surface of the reservoir; 20% has here been added to the runoff as calculated from those tables to cover evaporation. The drainage basin of San Mateo Creek ranges in elevation from 250 to 1,800 ft., with an average of about 750 ft. The hills are undulating. There is a limited growth of timber on the northern slopes near the summit, but a large amount of brush covers other portions of the basin. On the southern slopes and crest the hills are frequently bare of brush, but covered with grasses.

SALT SPRINGS VALLEY WATERSHED.—The basin of the Salt Springs Valley is largely of red clay, which scantily covers a bedrock of

granite and slate. The topography is undulating rather than mountainous, about 20% of the total drainage area being valley land. There is little brush or timber in the valley, and only a scattering growth of oak and scrubby pine on the hills. To obtain the mean for the basin 10% has been added to the rainfall for North Hill, six miles northwest of the dam. To obtain the total runoff for the basin 4,132 acre-feet has been added to the mean rainfall for the Kings River basin will be 37.8 ins.

MOJAVE RIVER.—The meteorological and hydrographic work of the Arrowhead Water Co. has been carried on for a number of years at the head of the Mojave River. Twenty-eight rain gages, carefully located at elevations of from 2,100 to 7,200 ft., have been maintained. The measurements of runoff from several tributaries have been



- ○ W. Portion of Peninsular Watershed, San Mateo Creek
- □ Sacramento River Watershed
- ◇ S.E. Portion of Peninsular Watershed, San Mateo Creek
- ▽ Above S.E. and N.E. Portion of Peninsular Watershed, San Mateo Creek
- ⋈ Cuyamaca Reservoir Watershed
- △ Sweetwater Reservoir Watershed
- + Arrowhead Reservoir Co.
- • Piru Creek Watershed
- × Salt Spring Valley Watershed
- ⋮ Stanislaus River Watershed
- ⋮ Tuolumne River Watershed
- ▲ San Joaquin River Watershed
- ■ Kings River Watershed
- ○ Ring enclosing Symbol indicates Mean Rainfall

FIG 2. ANNUAL AND MEAN RUNOFF FROM CALIFORNIA WATERSHEDS, BASED ON SEVERAL YEARS' OBSERVATIONS.

(Large areas are watersheds of 100 sq. miles or over. The general curve for California was determined in the fall of 1900.)

the amounts as given in the table on page 337, Part IV., of the 18th Annual Report of the United States Geological Survey, to compensate for evaporation from the reservoir surface.

The methods of measurement of discharge from the reservoir are very crude, which may partly account for the very high percentage of runoff from this basin, which contains 25 sq. miles.

STANISLAUS RIVER BASIN.—There were no rainfall data obtainable for this basin, but since it joins the Tuolumne and is in most respects similar, the rainfall for the Tuolumne basin has been taken to apply to both.

TUOLUMNE RIVER BASIN.—To obtain the mean rainfall for this basin the average elevation and area of the various portions were taken from the topographic maps of the U. S. Geological Survey. The areas were obtained by the use of a planimeter. La Grange was taken as the base station and the percentage of increase for the various elevations as shown by the diagram, Fig. 1. The following example for the year 1896 will illustrate more particularly the method:

Average elevation.	No. of sq. miles.	Estimated rainfall, 1896.	Mile-inches.
1,200	75	26.4	1,980
1,500	88	29.0	2,552
2,500	182	37.4	6,807
3,500	46	45.8	2,107
4,000	105	50.0	5,252
4,500	147	54.2	7,967
5,500	90	60.9	5,481
6,000	143	63.3	9,052
6,500	105	61.3	6,437
7,500	189	57.3	10,830
9,000	330	51.3	16,927
1,500			75,692

$$\frac{75,692}{1,500} = 50.3 \text{ ins. mean for basin, 1896.}$$

SAN JOAQUIN AND KINGS RIVER BASINS.

There was practically no rainfall data for either the San Joaquin or Kings River basins.

The estimated mean rainfall for the Tuolumne River basin for the years 1896-1899 is 48.2 ins.; the depth of mean runoff for the same period is 20.8 ins.; the depth of mean runoff for the San Joaquin River for this period is 18.4 ins. Since the topography, exposure, etc., in the two basins are similar, the rainfall will probably be proportional to the runoff.

Example: 20.8 : 18.4 :: 48.2 : 42.7. Similarly, made over weirs. The area of the basins are all less than 50 sq. miles. The watershed is covered with a thick growth of timber on the crest. The growth of timber diminishes as the desert is approached, the northern part of the watershed being covered with brush only. The mean elevation of the watershed observed upon is about 5,250 ft. above sea level.

CUYAMACA RESERVOIR WATERSHED.—The area of this watershed is 11 sq. miles and the mean elevation above sea level is probably 5,500 ft.

The runoff is carefully measured. There is only one rain gage maintained, and that is at the dam. The resident engineer, Mr. F. S. Hyde, says that as this rain gage is located between two high wooded peaks, which act as condensers of the moisture-laden clouds, the recorded precipitation is undoubtedly heavier than the average of the watershed. This probably explains why the mean annual runoff is so far below the general curve.

SWEETWATER RESERVOIR BASIN.—The evaporation and runoff records from this basin date from 1888, and have been very carefully kept.

There is no doubt that many of the points on the curves, Fig. 2, would be changed if we had more definite information as to the rainfall, but the curves are the best that could be made of the information at hand. The mean discharge for the period of observation on each stream is used, together with the mean rainfall for the same years. These means are considered the more satisfactory, as they tend to eliminate erratic stream and rainfall records.

A SWIVELING JOINT FOR A 16-INCH HIGH-PRESSURE STEAM MAIN.*

By R. E. Curtis,† M. Am. Soc. M. E.

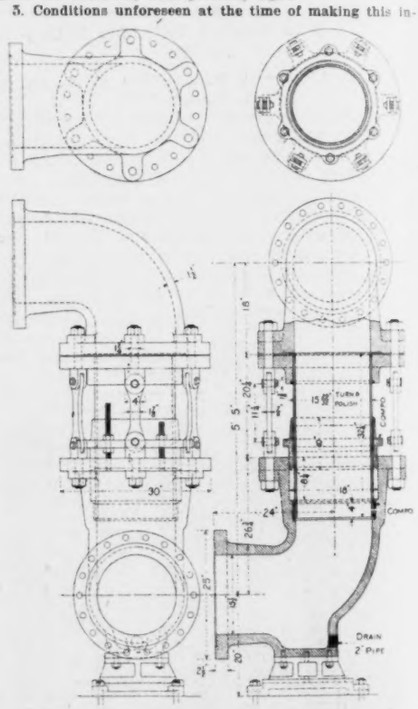
(1) All engineers will probably agree that slip or swiveling joints in steam lines are commonly undesirable. Nevertheless there are frequently cases in which some form of such joint cannot be avoided, and it becomes of importance to reduce their inherent disadvantages to a minimum. The swiveling joint here described was designed to meet a special situation, but its size and construction are such as, perhaps, to make it of [illegible] general interest. The problem presented was that [illegible] a full-sized connection between the ends of two [illegible]-in. mains, carrying 160 lbs. pressure, lying parallel [illegible] each other and of such length that the relative movement [illegible] of the ends by reason of expansion amounted at [illegible] to several inches.

(2) The first form of connection to suggest itself, and in all respects the most desirable, had it been practicable, was by a simple loop of pipe. A little calculation, however, showed that this could not be used without [illegible] of excessive stresses being set up. Then several forms of flexible connection were investigated, and the final design adopted as being on the whole most satisfactory [illegible] the following particulars: (a) Reasonable form and [illegible] sions; (b) form and arrangement of parts under [illegible]; (c) least number of joints requiring packing and [illegible] of those from points where water might collect. [illegible] details were designed for a working pressure of 225 [illegible].

(3) Each joint consists of two elbows held together by a system of links—a flange bolted to the upper elbow and a length of pipe projecting downward from the flange into a stuffing box formed in the lower elbow. Two of these joints are used, the lower elbows being secured to the ends of the mains and the upper elbows joined by a length of pipe. The elbows and flanges are of air-furnace cast-iron and are of substantial dimensions. The pipe is a piece of 16-in. outside diameter pipe, 15⅛ ins. inside diameter, finished smooth on the outside. The gland and the ring at the bottom of the stuffing box are of composition, the former being held in place by six studs, three of which are long enough to hold it in a position to allow the packing to be easily gotten at. The ring and each end of the gland are made easy fits about the pipe. The end-wise pressure is taken up, and at the same time the rotation of the joint provided for by six mild-steel links carefully fitted and so proportioned that the entire load can be borne by three with ample margin for safety. These links with their supporting bolts form a simple system, which assures a fairly even distribution of stresses and is always open to observation.

4. Each complete joint is carried by a sliding support consisting of a chair cast separately (to avoid complication of the pressure part) and bolted to the lower elbow and a bearing plate anchored to the masonry floor. The stuffing box was made of generous depth, and so proportioned that metallic packing could be employed if desired, but so far only asbestos packing has been used, and the joint has ordinarily been perfectly tight.

5. Conditions unforeseen at the time of making this installation have led to a radical rearrangement of the entire system of steam mains, so that a connection of this kind will no longer be needed, and the swivels will go out of service during the present year. However, had this not been done, there is every reason to believe that they would have continued to serve satisfactorily as long as any other part of the mains. Certainly they have in almost three years of service proven so satisfactory and required so little attention that there would be no hesitation about duplicating the construction under similar conditions.



A Swiveling Expansion Joint for a 16-in. High-Pressure Steam Main.

*A paper read at the Boston meeting of the American Society of Mechanical Engineers.

†Edison Electric Illuminating Co., 3 Head Place, Boston.